THE ENGINEER

APRIL 29, 1955

Institution of Civil Engineers

ON Thursday, April 22nd, the Institution of Civil Engineers held its annual dinner at the Dorchester Hotel in London. The toast of "The Institution" was proposed by Lord Waverley, chairman of the Port of London Authority. He remarked that great advances had been made in the past by engineers without any scientific background. But the engineer had since found it necessary to adjust his ideas. Structures were now expected to stand up to stresses and temperatures higher than ever before; and margins of safety had to be lower. There had to be understanding of phenomena such as creep, age-hardening and fatigue. It was especially welcome that there was to-day a close association of the Institution with the "Mechanicals" and "Electricals," particularly over technological education. The recent debate in the House of Lords on that subject did not satisfy him about the Government's intentions, which appeared to be to concentrate technological education around existing universities. He, personally, could not trust any one type of institution to supply all the answers to what was a complex educational problem. In reply, Mr. David M. Watson, president of the Institution, stressed the great tasks at home and abroad that engineers were undertaking and would have to undertake. Engineering firms were asking for more technologists; and universities said they could supply them provided they could extend their premises. But that was qualified by the difficulty of getting the right kind of boy to take up engineering. Schoolmasters lacked the knowledge and sympathy with engineering that would fit them to divine a boy's bent for engineering. Turning to another subject, he remarked that nowadays engineers had begun to go "cap in hand" to get work abroad. But the reputation of British engineers had been built up through their strict adherence to their etiquette; and he was not convinced that, through any slackening of that etiquette, engineers could expect to get any more than a temporary advantage. Mr. W. K. Wallace, vice-president of the Institution, then welcomed the guests and Mr. Lennox-Boyd, Secretary of State for the Colonies, replied.

Plastics Industry Education Fund

AN appeal is being made by the Plastics Industry Education Fund for subscriptions and donations which would permit it to extend its work. This week a progress report is being issued to all subscribers and to all firms which are members of the British Plastics Federation; and the chairman of the British Plastics Federation, Mr. Skan, mentioned the Fund in his speech at the Federation luncheon in London last Tuesday. At the moment the annual income of the Fund, which was founded in 1951 to take the place of what was formerly called the President's Fund, founded in 1942, amounts to about £5000, of which about £1300 goes in administrative and other essential expenditure. About £1000 a year is allocated to training grants to help young people enter or advance themselves in the industry. Another £2000 a year is diverted to bursaries at the Borough Polytechnic in London and at the Birmingham College of Technology, for students fresh from school. Money is also expended on the publication of monographs on certain subjects, upon the contribution to libraries of new textbooks, which students find too expensive to buy, and upon other activities with an educational context. The Trustees of the Fund feel that a net income of £3700 a year is inadequate to maintain the educational requirements of the industry. It is believed that administrative expenditure would be scarcely affected even if the gross income were doubled or trebled so that practically 100 per cent of any new contributions would be directly devoted to the objects of the Fund. The address of the Fund is at the Plastics Institute, The Adelphi, Adam Street, London, W.C.2.

Institution of British Agricultural Engineers

THE tenth annual general meeting of the Institution of British Agricultural Engineers was held in London on Friday last. The report of the council for 1954 recorded a further increase in membership, the total in all grades at the end of the year being 1334. The report also stated that last year thirty candidates were accepted for the examination for the National Diploma in Agricultural Engineering, and that nineteen were successful. At the meeting, the president, Mr. D. P. Ransome, announced that the council had decided to establish a study group co-ordinating committee, which, in co-operation with the Institution's local centres, would encourage the detailed examination of various technical problems from the farming and engineering aspects. Mr. Douglas Bomford was elected to succeed Mr. Ransome as president in October next, and Mr. C. A. Cameron Brown was elected a vice-president. At a luncheon which followed the annual meeting, the principal guest was the Minister of Agriculture, Mr. D. Heathcoat Amory, who proposed the toast "The Institution of British Agricultural Engineers." In the course of his speech, the Minister commended the Institution's educational activities and the efforts which it continued to make in order to achieve the highest possible standards in agricultural engineering. The Minister went on to emphasise the importance of the agricultural machinery industry, recalling that last year its production for the home market was valued at £40,000,000 and that its export sales reached a total of £52,000,000. British engineers, the Minister added, had earned a reputation not only for their technical ability, but also for their ability to show a patient concern for overseas needs. In his speech acknowledging the toast, the president, Mr. Ransome, suggested that there was a great need in this country for the establishment of a college where overseas students could study agricultural engineering. He expressed the hope that the Government would consider the matter when studying the question of funds for the development of the Commonwealth and Colonies.

Hydraulic Research in 1954

THE D.S.I.R.'s report on the work of the Hydraulics Research Organisation during 1954 has now been published. One of the most important investigations described concerns the behaviour of storm surges in the Thames Estuary. Particular attention was given to the effect that flooding bankside areas in the lower estuary might have on water levels at high tide in London, and to the efficacy of a gated structure across the river which could be closed before the predicted time of arrival of a surge. This work formed the subject of a paper at the Institution of Civil Engineers last autumn and was commented upon in a leading article in THE ENGINEER of October 29th last. Silting in Tilbury Docks is another problem on the Thames which the Station has been investigating. Approximately 80 per cent of the silt entering the docks does so during spring tides, the report states, when the lock gates swing open and the inflow of water carries a high concentration of mud. The Port of London Authority was recommended to impound the docks to a higher level, or alternatively "run-in" might be prevented at the old entrance but allowed to take place at the new entrance where the river water carries less silt. A device which held the lock gates shut would greatly reduce the amount of dredging required in the docks, it is pointed out. Radioactive tracers, consisting of "labelled" glass, ground to the same size as Thames mud, have been used in an experiment to discover if the method was a possible one for tracing the movements of mud. Other work in progress at the Hydraulic Research Station in 1954 included investigation of the behaviour of the proposed extensions to Lyttleton Harbour in New Zealand, three alternative schemes being investigated. Experiments on a model of Southwold Harbour, which included the use of a self-propelled model boat, were also in progress, to find out what were the wave effects on shipping entering and leaving the harbour; the boat was photographed with a slow motion camera. Five modifications to the harbour entrance have been tested. One of them proved to be fairly successful, but others are to be tried. Plans were also being prepared for the second and larger of two models necessary to investigate the Shrewsbury flood relief scheme. The Station also carried out work on another scheme for the River Severn—the proposed Maisemore Barrage, and designed an air-regulated spillway syphon for two falls on the Manaquil branch canal for the Sudan Irrigation Department. The function of the syphons is to maintain a constant upstream water level in the canal over a large range of discharges. Model tests indicated that the syphon could pass 10 per cent more than the designed full supply before reaching the safe limit of operation at which air-regulation ceases and the syphon runs full-bore.

Glasgow's Waterworks

THE presidential address of the Scottish Section of the Institution of Water Engineers was delivered in Glasgow on Friday last, April 22nd, by Mr. S. D. Canvin, the chief engineer and manager of Glasgow Corporation's Water Department. Mr. Canvin spoke of the development of the water supply of the city over the years, and of some of the efforts now being made to improve and enlarge the facilities available. Amongst the numerous statistics which he gave during the course of his address, we were interested to note that the average water consumption in Birmingham, Liverpool, London and Manchester, taken together (for 1950), was 44·6 gallons per head per day. The four Scottish cities of Aberdeen, Edinburgh, Dundee and Glasgow, however, averaged 57·9 gallons per head per day, with Glasgow at the head of the list with a figure of 69·0. Work on the utilisation of the Glen Finglas catchment for Glasgow's water supply has now been started (see THE ENGINEER, February 25, 1955); a tunnel aqueduct and a low intake weir are to be built and, if necessary, a dam can be constructed later should it become necessary to develop the Glen Finglas catchment further. An explanation of the considerable financial benefit obtained by constructing the scheme in separate stages in this manner was given by Mr. Canvin at the conclusion of his address.

Discharge of Gas from Cylinder to Atmosphere

By R. S. BENSON, M.Sc. (Eng.), A.M.I.Mech.E., A.M.I.Mar.E.*

No. II—(*Continued from page 548, April 22nd*)

The discharge of gas from cylinder to atmosphere is analysed by the method of characteristics. It is shown that for isentropic flow a depression can occur in the cylinder under all conditions immediately at the end of the discharge, the magnitude depending on the ratio of the port area to cylinder cross-sectional area. The duration of the depression depends on the initial pressure and temperature, cylinder length and ratio of port area to cylinder cross-sectional area. Excepting in the case of certain low release pressures the magnitude of the depression is independent of the release pressure. The analysis also indicates that the mode of the discharge is different for gradual port opening compared with sudden port opening, the magnitude of the depression depending on the port area at the end of the discharge. By an approximate method the possibility of a depression occurring in two-stroke-cycle engines is examined. Curves are produced showing the port area at the end of the discharge as a function of cylinder stroke-bore ratio, port width, release pressure and temperature, cylinder length and engine speed. These curves confirm that a depression can be obtained more readily with through-scavenged engines, with a high stroke-bore ratio, earlier exhaust port opening and with a high engine number (engine speed × cylinder length).

(3) Application of Method of Characteristics to Flow from a Cylinder to Atmosphere

(*a*) *Sudden Opening of Ports of Close Cylinder: Characteristic Diagrams, Figs.* 1 *and* 2.—In order to compare this method with published results for the finite wave theory, a pressure of 30 lb per square inch gauge, temperature 60 deg. Fah., cylinder length 4ft and port area ratio $\Phi=\frac{1}{4}$ have been used, these conditions correspond to Figs. 34, 35 in Mucklow and Bannister's paper.[3] The numbering of the characteristics follows the usual practice,[4, 5] the state of the gas in the position diagram corresponding to the number of the upper nodal point.

On sudden opening of the port the state of the gas at the open end falls along the characteristic 05. This characteristic is subdivided to produce a fine mesh for accurate analysis. The indicator diagrams (Fig. 3) at the positions $x=\frac{L}{12}$ and $x=\frac{11}{12}L$ were obtained by converting the state points to pressure by means of the curve on the left-hand side of the state diagram. As would be expected, the pressure drops in stages; there is excellent agreement between Fig. 3 and the calculated diagrams by Mucklow and Bannister, except at the points *F* and *G*. The calculated depression by the method of characteristics is 1·4in Hg compared with 0·2in Hg by the finite wave theory and the observed value of 1·6in Hg. The difference between the two calculated values is due to the assumptions made in the last stage of the discharge.

In the method used by Mucklow and Bannister the particle velocity distribution in the wave front is assumed to be linear for the whole discharge process, both sonic and subsonic. Under these conditions the pressure function $(p/p_e)^{1/7}$ in the wave front is linear and the boundary curve assumed to be a straight line or a series of straight lines. For sonic conditions (equation 29, Fig. 4) this is correct and for a short period of subsonic flow the assumption is justified by the shape of the curve. At the end of the discharge period there is, however, a noticeable change in shape of the boundary curve. The wave propagated into the cylinder during this period will, on leaving the ports, have a non-linear velocity distribution and certain points in the wave front on reflection at the closed end will produce a transient pressure drop greater in magnitude than the final pressure, the final pressure being the pressure corresponding to the dwell period. The non-linear velocity distribution in effect produces a "trough" of low pressure at the closed end. The characteristics of the points in the wave front producing the minimum pressure are shown in the enlarged state diagram Fig. 2 (state points 96, 102, 108). The characteristic corresponding to the minimum pressure is tangential to the boundary curve.

It is therefore possible for the dwell pressure, or stage pressure represented by the pause in the pressure crank angle diagram, to be higher than the pressure in the wave front at the closed end. This will occur for multi-stage discharge and the magnitude of the depression will depend only on the area ratio. This follows from consideration of the state diagram where it will be seen that the minimum pressure corresponds to the characteristic tangential to the boundary curve. Except for this one point there is complete agreement between the finite wave theory and the method of characteristics for sudden discharge. To establish the numerical relationship between the magnitude of the depression and the port area ratio a further analysis of the pressure conditions in the cylinder deduced from the method of characteristics will be given.

Above the critical pressure the ratio of the pressure at the commencement of each stage to the pressure at the end of each stage for sudden port opening is constant for a given area ratio; this arises from the geometry of the state diagram. It should be noted that a discharge stage is defined as the period between dwells at the closed end. The boundary lines for sonic flow are linear, and pass through the point $\Delta=0$, $V=0$, the characteristics of the wave points are orthogonal at the boundary line, hence if $m=\frac{V_c}{\Delta_c}=\Phi\left(\frac{p_1}{p_t}\right)^{-6/7}$ it can be shown that the relationship between the pressure function $\Delta_a=\left(\frac{p_a}{p_e}\right)^{1/7}$ at the beginning of the discharge stage and the pressure function $\Delta_b=\left(\frac{p_b}{p_e}\right)^{1/7}$ at the end of the discharge stage is

$$\Delta_b=\Delta_a\left[\frac{5-m}{5+m}\right] \quad . \quad . \quad . \quad . \quad (30)$$

where

$$\Delta_a>\Delta_c+\frac{V_c}{5}.$$

In terms of pressure equation (30) can be written

$$\left(\frac{p_b}{p_a}\right)^{1/7}=\left[\frac{5-\Phi\left(\frac{p_1}{p_t}\right)^{-6/7}}{5+\Phi\left(\frac{p_1}{p_t}\right)^{-6/7}}\right] \quad . \quad . \quad (31)$$

where $\frac{p_1}{p_t}$ is the critical pressure ratio. Equation (31) corresponds to equation (64) in Mucklow and Bannister's paper.

If the discharge proceeds from Δ_0 then at the end of the first stage

$$\Delta_{b1}=\Delta_0\left[\frac{5-m}{5+m}\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (32)$$

at the end of the second stage

$$\Delta_{b2}=\Delta_{b1}\left[\frac{5-m}{5+m}\right]=\Delta_0\left[\frac{5-m}{5+m}\right]^2$$

at the end of the *n*th stage

$$\Delta_{bn}=\Delta_0\left[\frac{5-m}{5+m}\right]^n=\Delta_0\left[\frac{5\Delta_c-V_c}{5\Delta_c+V_c}\right]^n \quad . \quad (33)$$

in terms of pressure

$$\frac{p_n}{p_0}=\left[\frac{5-\Phi\left(\frac{p_1}{p_t}\right)^{-6/7}}{5+\Phi\left(\frac{p_1}{p_c}\right)^{-6/7}}\right]^{7n} \quad . \quad . \quad (34)$$

In equations (32) and (33) m is a function of Φ only and the stage ratio $\frac{\Delta_a}{\Delta_b}=\left(\frac{p_a}{p_b}\right)^{1/7}$ is, therefore, a function of Φ only; this is shown in Fig. 5.

For subsonic conditions the relationship between Δ_a and Δ_b can be computed by the following expression

$$\frac{\Delta_b}{\Delta_a}=\frac{\Delta-\left[\frac{\Delta^2-1}{5\left(\frac{\Delta^{10}}{\Phi^2}-1\right)}\right]^{1/2}}{\Delta+\left[\frac{\Delta^2-1}{5\left(\frac{\Delta^{10}}{\Phi^2}-1\right)}\right]^{1/2}} \quad . \quad . \quad (35)$$

where $1<\Delta<\Delta_c$, this is derived direct from the geometry of the characteristic diagram. Δ_b is plotted against Δ_a in Fig. 6 for various area ratios, since $\Delta_b=\left(\frac{p_b}{p_e}\right)^{1/7}$ and $\Delta_a=\left(\frac{p_a}{p_e}\right)^{1/7}$ these curves also give the relationship between the pressure at the beginning of a discharge stage and the pressure at the end. It will be seen that for a wide range of positive pressures represented by $\Delta_a>1$ at the commencement of the discharge stage the pressure at the end of the stage will be less than atmospheric when p_e is atmospheric pressure. For increasing area ratio the magnitude of the depression increases; at the same time the range of initial pressures from which a depression may be caused also increases, a fact first noted by Giffen.

The effect of release pressure (i.e. pressure at commencement of discharge) on the magnitude of the depression can be studied from these curves in conjunction with the state diagrams. For a given area ratio increasing the release pressure from 1 atmosphere absolute increases the magnitude of the depression up to maximum value. At this point $\Delta_a=\Delta_m$, and the characteristic through $(0, \Delta_m)$ is the normal to the boundary curve. A further small increase in release pressure will cause the "dwell" pressure at the end of the stage to increase above the minimum value referred to above. The magnitude of the minimum pressure, how-

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ever, will remain constant, this pressure will occur after the dwell period referred to above and before the pressure again rises in the cylinder on return flow. The subsequent increase in depression is due to the slope of the wave front. The head of the wave arrives at the open end before the pressure in the cylinder adjacent to the port has dropped to 1 atmosphere absolute, since the process is continuous, therefore, a new wave is propagated into the cylinder which on reflection will produce a further transient pressure drop at the closed end. The tail of the new wave corresponding to the end of the previous wave will, on reflection at the closed end, produce an increase in pressure and the pressure in the cylinder will rise due to return flow. Further increase in release pressure will increase the " dwell " pressure at the end of the discharge stage, but for the same reasons as above the magnitude of the depression remains the same.

For all release pressures above that corresponding to the pressure function Δ_m referred to above, the magnitude of the depression is a function of the area ratio. For a given area ratio Φ the minimum pressure will occur when $\Delta_a=\Delta_m$ at this point.

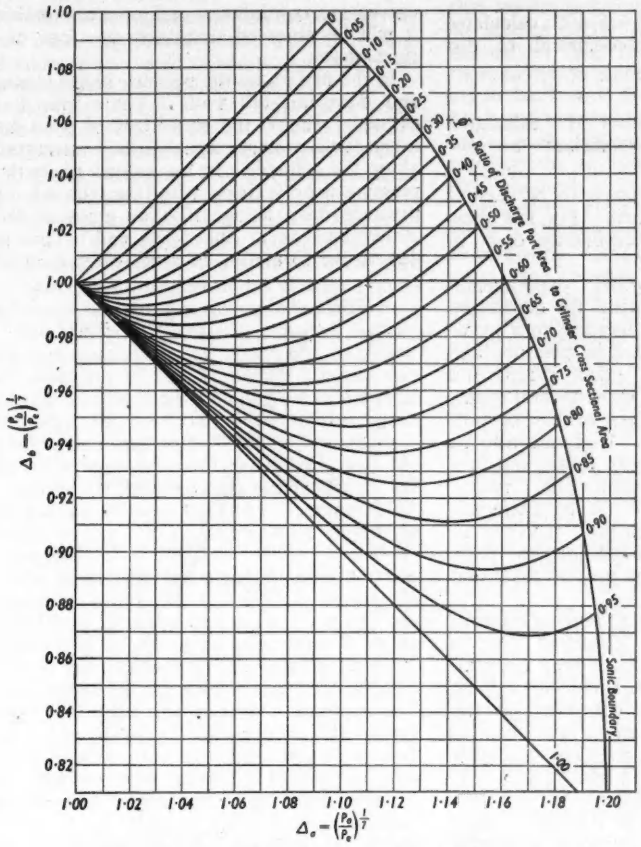
$$\frac{[\Delta_a^2-\Delta_b^2]}{[(\Delta_a+\Delta_b)^2-1]}\left[1-\frac{25(\Delta_a-\Delta_b)^2(\Delta_a+\Delta_b)^2}{2^{10}\Phi^2}\right]=1 \quad \ldots\ldots (36a)$$

and

$$\left[\frac{[\Delta_a+\Delta_b]^{10}}{2^{10}\Phi^2}-1\right]=\frac{(\Delta_a+\Delta_b)^2-4}{5(\Delta_a-\Delta_b)^2} \quad \ldots\ldots (36b)$$

Fig. 5 shows the minimum pressure for area ratios from 0 to 1. In the case of single stage discharge, i.e. below the release pressure corresponding to $\Delta_a=\Delta_m$, the minimum pressure is dependent on the initial pressure. In all cases the minimum pressure increases with release pressure.

In considering the duration of the depression it will be seen that the length of the wave front increases with decreasing pressure (*cf.* $Z=1\cdot5$ and $Z=7$ in Fig. 1). For a given cylinder length the wave front increases with increasing number of discharge stages, thus with increasing cylinder release pressure the duration of the depression increases. Furthermore, since for a given release pressure $dZ=\frac{a_0 dt}{L}$ =constant the duration dt of the depression will increase with cylinder length and decrease with increasing temperature. Both the magnitude and duration of the depression will increase with increasing effective port area/cylinder cross-sectional area ratio.



Δa Dimensionless acoustic velocity at beginning of discharge state.
Δb Dimensionless acoustic velocity at end of discharge state.

Fig. 8—Chart giving relationship between Δa and Δb for sub-sonic conditions assuming discharge direct to atmosphere

In the above treatment the effective port area has been considered to be constant. Since however the coefficient of discharge of the port will decrease with pressure the effective area will drop during the discharge period. Hence, as it will be seen from Figs. 5, 8, the stage pressure drop will decrease and the depression will be smaller than if a constant area were assumed. The reduction in stage pressure ratio was observed by Mucklow and Bannister,[3] this was attributed to friction in the cylinder. It is considered, however, that this was more probably due to the reduced

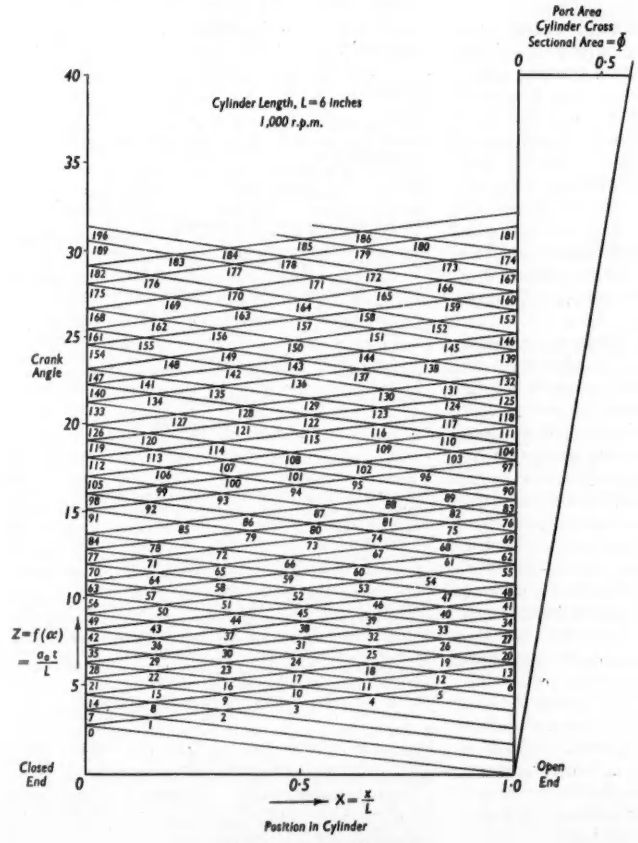


Fig. 6—Position diagram

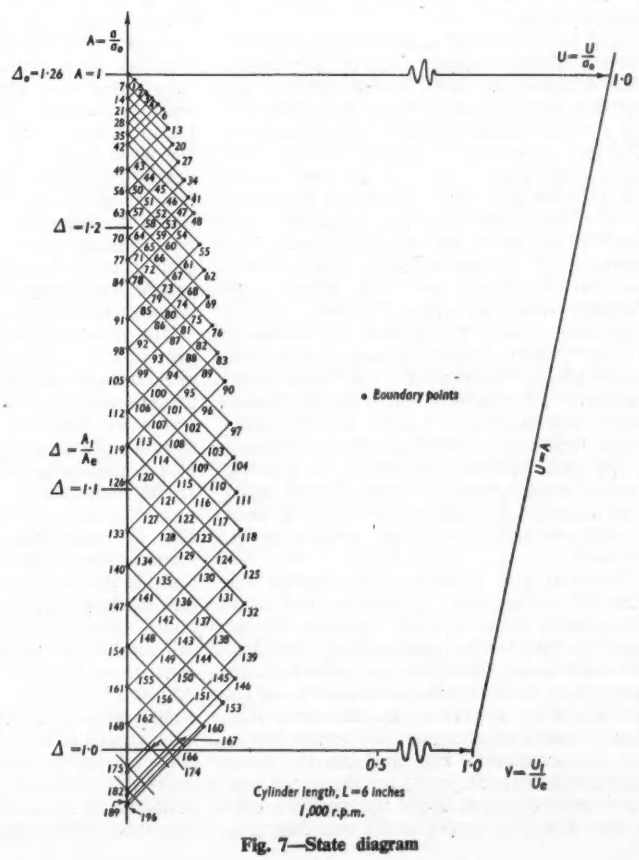


Fig. 7—State diagram

effective port area. Scaling their diagram, the following approximate calculation was made for the first and second stage of the discharge.

For first stage :

Pressure ratio $p_a/p_b=1\cdot415$; calculated $\Phi=0\cdot21$; average coefficient of discharge=0·85.

Second stage :

Pressure ratio $p_a/p_b=1\cdot31$; calculated $\Phi=0\cdot18$; average coefficient of discharge=0·72.

These values would appear to be reasonable for the stage pressures. For low pressures there will a corresponding drop in effective port area.

Comparison with other experimental work[7, 8] shows that in general the depression in the cylinder tends to increase to a maximum value with increase in pressure and increase in port area. Exact comparison between the theory and experimental results cannot be made due to lack of data on port coefficients of discharge. It should also be noted that for large port areas and low release pressures the duration of the " peak " minimum pressure tends to be extremely small and difficult to measure ; it would be expected that for these conditions the theoretical depression will be greater than that measured.

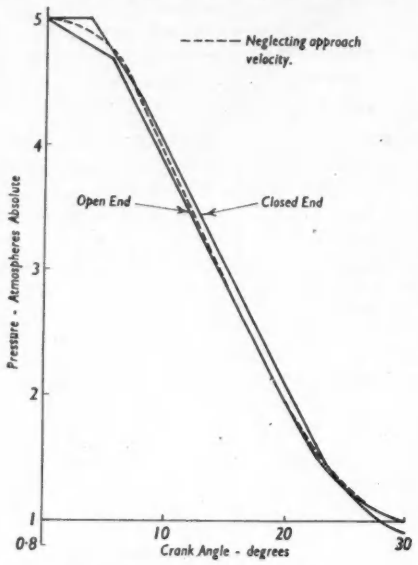
(3) (*b*) *Gradual Opening of Ports of a Closed Cylinder : Characteristic Diagrams Figs.* 6 and 7.—In this case, which closely approximates to the two-stroke cycle engine, the boundary conditions are controlled by the rate of port opening. If small time intervals are taken the boundary curve (Fig. 4) appropriate to the port opening area ratio at the end of the time interval is used.

It can be considered for descriptive purposes that the discharge process is carried out by the propagation of a series of small negative pressure waves from the ports into the cylinder, the pressure falling in the cylinder in a continuous manner. The whole process can be analysed by the method of characteristics.

Fig. 6 shows the characteristic diagram for a cylinder 6in long. The initial pressure and temperature are 5 atmospheres and 520 deg. Fah. absolute. The ports are opened by a sleeve running at 1000 r.p.m., the effective port area ratio varying linearly with crank angle from 0 to 0·6 in 36 deg. In this analysis the generalised boundary chart was used as the basis of the state diagram ; this involved the use of non-uniform scales. The ordinate Z of the position diagram was selected so that the port area crank angle diagram could be directly plotted on the right-hand side. To increase the accuracy of the graphical solution large scales and small meshes were used ; the time increments of the successive waves on the Z scale being equivalent to 0·9 deg. The following scales were used : position diagram, Z scale 0·746 unit per inch (equivalent to 2 crank angle degrees per inch), X scale 10in per unit ; state diagram, V scale 10in per unit, U scale 12·6in per unit ($\Delta_0=1\cdot26$), A scale 62·4in per unit.

To start the characteristic diagram the time for a single wave to pass up and down the cylinder was calculated. This was divided into six increments equivalent to 0·9 deg. of crank angle, and the area ratio Φ corresponding to each increment was used to obtain the boundary conditions on the state diagram. The characteristics are numbered in the usual manner. Fig. 9 shows the pressure-crank angle diagrams for the closed and open ends obtained from the position diagram. It will be seen that the two diagrams are out of phase, the pressure at the open end being lower than the pressure at the closed end, except at the end of the discharge process, when the reverse occurs. With the large number of characteristic points the curves are continuous, and on examination it will be observed that there are four distinct phases.

In the first phase the pressure at the closed end does not fall until a short time has elapsed ; this is the equivalent of the time taken for a pressure signal to be transmitted along the cylinder. In the second phase the pressure drop is linear with time, the rate of pressure drop being twice as great at the closed end as at the open end. This is due to the formation of a non-steep-fronted



Characteristic diagrams Figs. 6 and 7
Engine speed 1000 r.p.m.
Cylinder length, 6in

Fig. 9—Calculated indicator diagram for cylinder with gradually opening ports

finite expansion or negative wave of the same type as in the sudden discharge case. This negative wave is propagated from the ports into the cylinder ; the wave front is longer than the cylinder length due to the time required for the port to open, the slope of the wave front being a function of the port opening rate. On the characteristic diagram this is due to the combination of the small waves of amplitude 0·1, 1·2, 2·3, 3·4, 4·5, 5·6, into one wave of magnitude 0·6. The high rate of pressure drop at the closed end is due to the reflection of the large single wave at this point.

The third phase of the discharge process produces a pressure-crank angle diagram of the usual form. In analysing the discharge process two hypotheses can be postulated. In the first it may be considered that gradual opening of the ports causes the propagation of a series of small waves amplitude 6·13, 13·20, &c., which gradually increase the particle velocity in the cylinder to accommodate the increasing port opening. In the second hypothesis it may be considered that the discharge process is basically carried out by a large finite pressure wave of the form noted in the second phase, the particle velocity in the wave front being increased continually by the boundary conditions at the port. In both cases the regular pattern of the pressure drop can be obtained. The long pauses of the pressure/crank angle diagram for sudden discharge are not present, since the non-steep wave takes a longer period to form and the wave front is greater than the cylinder length, thus producing the uniform pressure drop. In calculating the pressure drop for this phase the assumption of single finite negative pressure waves moving up and down the cylinder would have to be modified to allow for the slope of the wave front, and for this purpose the hypothesis of a large number of small finite waves appears to be more amenable to analysis.

The fourth phase occurs when the pressure at the closed end is lower than the pressure at the open end. The flow is still towards the ports ; the pressure difference is due to the reflection of the waves at the closed end. The large number of small waves comprising the single wave on reflection at the closed end successively reduce the pressure to a minimum value corresponding to the minimum pressure for the port area ratio. In this case the hypothesis of small waves propagated from the open end enables a more logical explanation to be forwarded, since it may be inferred that with the irregular particle velocity distribution in a wave front of a large finite wave, the wave front would collapse on reflection at the closed end and degenerate into a series of small waves.

It is therefore suggested that in the case of discharge from a cylinder with gradually opening ports the process is different from the case with sudden opening, and in particular the presence of one finite wave can only definitely be observed at the commencement of the discharge process. The major part of the discharge process is either produced by the propagation of a large number of small finite negative pressure waves from the ports or by the propagation of large negative pressure waves having long wave fronts. The minimum pressure is controlled by the area ratio at the end of the discharge period. In the example given the minimum pressure was −2 lb per square inch and the port area ratio 0·45.

From the above conclusions it may be inferred that the depression in the cylinder will increase with release pressure and engine speed if the port area ratio increases with engine speed. If the port area ratio does not increase, then the depression will have the same maximum value for all release pressures and engine speeds once the ports are fully opened.

[1] " The Flow of Gases in Large Two-Stroke-Cycle Diesel Engines," Benson, R. C. J. S. Dissertation for M.Sc. (Eng.), London University, 1954.

[2] " Rapid Discharge of a Gas from Vessel into Atmosphere," Giffen, E., *Engineering*, Vol. 150 (1940), page 134.

[3] " Wave Action Following Sudden Release of Compressed Gas from a Cylinder," Bannister, F. K., and Mucklow, G. F., *Proc. I.Mech.E.*, Vol. 159 (1948), page 269.

[4] " Non-Stationary Problems of Gas Dynamics (Pressure Waves of Large Amplitude)," R. Sauer (Ministry of Supply Theoretical Research Translation 1/47).

[5] " The Application of a Graphic Method to Some Dynamic Problems in Gases," Haller, P., *Sulzer Technical Review*, 1945, No. 1, page 6.

[6] " Berechnung und Modellversuche über Druckenwellen Grossen Amplituden in Auspuff-Leitungen," Jenny, E. (Doctors Thesis Z.T.H.S., 1949).

[7] " The Kadenacy Effect," Schweitzer, P. H., Overbake, C. W. Van, and Manson, L., *Engineering*, Vol. 160 (1945), page 241.

[8] " Sudden Discharge of Air from a Pressure Vessel," Davies, S. J., *Engineering*, Vol. 149 (1940), page 17.

(*To be concluded*)

BRITISH GRAVITY SURVEY.—The Admiralty states that observations intended to increase scientific knowledge of the earth's crust are to be made by H.M. Submarine " Acheron " during a voyage round the Cape of Good Hope to Trincomalee and back through the Mediterranean. Such gravity surveys depend essentially upon the variations in the period of a pendulum. Differences in the composition of the earth's crust produce differences in the effect of gravitational pull, and therefore can be detected by pendulum readings. Gravity surveys of that portion of the earth's crust which is below the ocean can only be made from submarines which, when submerged, are not subject to wave motion and therefore provide a level platform on which variations in the motion of the pendulum can be observed. The " Acheron " is expected to return to the United Kingdom in about six months' time. The forthcoming gravity survey will be in the South Atlantic and Indian Ocean, where extensive observations will be made. It is in response to a resolution passed by the General Assembly of the International Union of Geodesy and Geophysics requesting all maritime powers to carry out as far as possible soundings and gravity measurements in those of the oceans which have not yet been explored.

What are Fair Wages?

By GERTRUDE WILLIAMS

THE Court of Inquiry which was appointed by the Minister of Labour and National Service to inquire into the railway dispute last December issued an Interim Report after only four or five days of investigation—a report which created something of a minor sensation. Most of the bodies which function as part of the statutory machinery for industrial conciliation and arbitration punctiliously refrain—and for very good reasons—from setting forth the basic principles on which their recommendations are founded. They know from experience that there is always much more likelihood of getting agreement on concrete proposals than on the principles which should govern them. But the Railway Court of Inquiry had no such fears. "We feel," they reported, "that we must state in the plainest of terms what we apprehend to be the proper approach. The Nation has provided by statute that there shall be a nationalised system of railway transport, which must therefore be regarded as a public utility of the first importance. Having willed the end, the Nation must will the means. This implies that employees of such a national service should receive a fair and adequate wage, and that, in broad terms, the railwayman should be in no worse case than his colleague in a comparable industry."

This was hailed by the railwaymen as coming down on their side and by the Transport Commission as absolving them from all future responsibility for finding the means to pay wages, whatever their level. On first reading, it has a plausible sound and seems to offer guidance in the settlement of the dispute. But coming down to brass tacks, what, in fact, does it mean? What is a fair and adequate wage? What is a "comparable" industry and who is the railwayman's "colleague" in such an industry? It is, indeed, just because of the impossibility of answering such questions in any rational way, or, even, in a way that would command general approval, whether rational or not, that the supreme difficulty of wage negotiations exists. We bandy these words about as if we really knew what we meant when we use them whereas, in practice, like Humpty Dumpty in *Alice in Wonderland* we make them mean whatever we want at the moment.

The only legal definition of "Fair Wages" is that attached to the term in Government contracts. Most such contracts include a "Fair Wages" clause, the aim of which is to ensure that firms selling goods or services to the Government shall be "good employers." It is the duty of any government department to see that every firm tendering to it observes certain conditions, and has done so for a period of at least three months before sending the tender. The chief of these conditions are :—

(*a*) The contractor shall pay rates of wages and observe hours and conditions of labour not less favourable than those established for the trade or industry in the district where the work is carried out, by machinery of negotiation or abitration to which the parties are organisations of employers and trade unions respectively, comprising substantial proportions of the employers and workers engaged in the trade or industry in the district.

(*b*) In the absence of any rates of wages, hours or conditions of labour so established the contractor shall pay rates of wages and observe hours and conditions of labour which are not less favourable than the general level of wages, hours and conditions observed by other employers whose general circumstances in the trade or industry in which the contractor is engaged are similar.

All that is meant by fair wages here is that the firm shall not undercut other firms in the industry. Whether the wages paid by such firms are "adequate" or not does not enter into the matter, nor is there any question of comparing the rates with those of any other groups of workers in other occupations. The "fairness" and the "comparison" are alike in referring to the conditions of employment of competing firms in the same industry.

But this is not what the Court of Inquiry Report was considering. There was, of course, no question of the Transport Commission paying less than other employers in the same industry, for it is the sole employer. The comparison was with "similar" workers in other occupations, and it evidently had not occurred to those signing the report to ask themselves if there were any "comparable" workers and, if so, how they might be identified.

On what can the comparability between types of worker be based? It cannot be the degree of skill required, for how can one assess one skill in terms of another? Is the lawyer more or less skilled than the doctor? And how does the soldier rate with either? Nor can it be the relative "importance" or "responsibility" of the job. The driver of an express train has more lives depending on his care and judgment than a surgeon performing a dangerous operation; but I doubt if the Court of Inquiry were thinking of the surgeon as the railwayman's "colleague" in a comparable employment. Is it the time it takes to train for the job? But in some jobs, and this is particularly true of managerial work, the skill is acquired not so much through a specific training taking so many years, but from a gradual growth of experience and understanding.

Recently there has been a good deal of uneasiness on account of the serious shortage of science teachers in grammar schools. We realise that our future wealth, and perhaps, even our existence, may depend on an increasing flow of highly-trained scientists and the science faculties of the universities have accordingly expanded very greatly. But the universities necessarily depend for their undergraduates on the products of the grammar schools, and the schools are finding themselves unable to provide the facilities needed to produce good potential scientists. For the modest salaries paid to schoolmasters cannot compete with the much better pay that scientists can earn in industry and in Government service. A scientist of only average qualifications can expect to get considerably more in industry by his late thirties than a first-class man can get as his maximum as a schoolmaster, with the result that many schools cannot get a science master at all (with the exception of those honoured few for whom teaching is a vocation, whatever the financial sacrifice involved), or else they must be content with the man who just scraped through his degree examinations.

In such circumstances, what does "fairness" dictate? Which is the "comparable" worker with whom the science master's pay should be equated? Is it the scientist employed in industry? In that case he will receive a much larger salary than his colleague in the class room who teaches history or Latin. Or is it his fellow schoolmaster? In that case, the school has to do without the science master.

Indeed, if we are honest with ourselves we will admit that when we think of people in comparable jobs, what we really mean is that we are accustomed to thinking of them as getting pretty much the same sort of income, or that their earnings have enabled them to live on much the same standard. We argue backwards from the earnings to the work and not the other way round; though we can generally think up all sorts of ingenious explanations to justify the relationship we have assumed.

One of the great troubles of all wage disputes is that all our ideas about wages are so confused. Most of us hold at one and the same time theories about what wages are, and ought to be, that are quite incompatible with one another. But this does not prevent us from upholding these irreconcilable ideas with passionate fervour.

Take, for example, the two most common demands—the "living wage" and the "rate for the job." For 150 years the trade unions have organised to establish and maintain a living wage, defined as the amount necessary to enable workers to live and bring up their families on a decent standard. From the first they protested passionately against the conception of the worker as a mere commodity whose services could be bought and sold in the market—simply factory fodder. They insisted on keeping in the forefront of all wage discussions the worker's needs as a human being, with his responsibilities to his wife and children. And this emphasis has had a profound influence on the climate of opinion. There are few people now who would be prepared to deny the responsibility of society for ensuring that workers earn enough to maintain themselves and their families on a level that the community accepts as the minimum tolerable in a civilised community. And the value of a wage in terms of the standard of living it would buy has always been a dominant factor in all wage negotiations.

Yet at the same time, the form of the wage agreement demanded by the trade unions cuts completely across this concept of the "living wage" as the basis of wage rates; for experience soon showed that the only hope of safety lay in establishing "occupational rates"—the "rate for the job"—irrespective of the particular individual employed. Only in this way could collective agreements be made effective and undercutting be prevented. A great deal of trade union policy has come to be bound up with measures to protect the rate for the job—particularly the strict adherence to the lines of demarcation between those permitted to do a certain job and those not, or the insistence on the ratio of apprentices to fully qualified adult workers, and the maintenance of wage differentials. For the occupational rate is based, not on the human needs of the worker, but on the differences in skill or accumulated experience of the various types of worker; and in all industries there are well-marked divergences between the wages of skilled, semi-skilled and unskilled grades.

Yet the human needs of the unskilled worker are the same as those of the skilled in similar domestic circumstances. And even if we admit that it is impossible to fix a wage that takes account of individual circumstances but must think of a group as a whole, there would be strong grounds—on the basis of the "living wage"—for paying the unskilled labourer more than the craftsman; for, according to the 1951 Census, the family of the average unskilled labourer is 40 per cent larger than that of the skilled man. Yet such

a revolutionary suggestion has never been put forward by a trade union and it would certainly lose its skilled members if it did. The skilled worker demands more than the labourer because he reckons he is "worth" more. In what sense "worth more"? Obviously not as a human being, but as an economic asset to the firm; and unless more is paid for skill there are not enough people who find it worth while to undergo the long period of training that leads to skilled status.

During recent years wage differentials between skilled and unskilled have narrowed considerably. This has not been a sudden movement but a fairly prolonged process, for the factors which have brought it about have been operating since the first world war, but the effects have become more noticeable in the circumstances of the last decade. In most industries employing apprenticed skilled craftsmen, the rates of pay of unskilled workers remained at 50 to 65 per cent of the skilled worker's rates throughout the nineteenth century. Indeed, H. Phelps Brown has calculated that in the building industry, which includes many crafts in which there has been little technological change throughout the centuries, the craftsman's differential remained stable at 50 per cent more than the labourer's pay from the time of Agincourt until 1914. By 1925, however, the labourer was getting 75·5 per cent of the skilled rate and by 1950 84 per cent.

The Oxford University Institute of Statistics has published an analysis which shows a similar trend in other industries. In shipbuilding, for example, the unskilled earned 55 per cent of the skilled rate in 1914, 68 per cent in 1928, and 81·5 per cent in 1950; in engineering, the comparable proportions were 58 per cent in 1914, 71 per cent in 1928 and 84·5 per cent in 1950.

Many factors have combined to produce this result, of which two wars in which the whole manpower had to be mobilised, are not the least. During an acute manpower shortage there is a premium on bodies, or, at least, on hands, whether they are skilled or not; and the effect of the recent war, with its prolonged acute need for labour of all types, has narrowed the differentials not only between skilled and unskilled, but between men and women and between young and adult. As it was impossible to add quickly to the ranks of the skilled—for skill takes about five years to acquire—a good deal of the inventive genius of the nation was focused on the breakdown of skilled jobs into semi-skilled processes; and, moreover, the fact that unskilled men were early drafted into the armed forces, whilst many of the skilled were reserved, increased the relative scarcity of the unskilled.

To a certain extent, the narrowing of differentials has been due to official wage policy and the restraint of the trade unions in public-spiritedly co-operating with the Government during the "wage freeze." When Sir Stafford Cripps urged the unions not to take advantage of their bargaining position to force wages up while it was still impossible to produce adequate quantities of consumable goods for the increased wages to purchase, he made an exception in favour of the lower paid workers for whom, on compassionate grounds, a case for higher pay might be made out. And, in consequence, the rates of the lower paid workers went up much more proportionately than those of the men already earning reasonably good wages. The Trades Union Congress was very concerned about this, and expressed its belief in the importance of safeguarding wage differentials so as to sustain the standards of craftsmanship; but it felt that, for the moment, the overriding essential was to see that costs and prices did not get out of control.

Yet, although the Trades Union Congress has stressed the need to retain adequate incentives to induce workers to qualify for skilled jobs, the policy of the trade unions as a whole has been the principal influence in the opposite direction. To a certain extent, perhaps, this has been by inadvertence rather than by design. Throughout the greater part of the post-war years, the prime spur to wage demands has been the rise in the cost of living, and as the basic necessities are of equal, if not more, importance to the lower income groups, demands have usually taken the form of a flat-rate increase to all concerned. Ten shillings on a labourer's wage is, of course, a much higher proportionate increase than on that of a craftsman, and narrows the relative gap between them. The skilled workers in the unions have been somewhat restive at this treatment, and it is noteworthy that in 1953 the wage increases in the engineering industry changed over from a flat-rate increase to a percentage one. And again, in the most recent rise in wages, the increase to the skilled workers was 11s., compared with that of 8s. to the unskilled grades. No doubt the craft unions would have liked a still bigger difference, for this still leaves the labourer's rate at 85 to 86 per cent of the craftsman's; but the Confederation of Shipbuilding and Engineering Unions caters for all grades of worker, and it is this development of the comprehensive, all-embracing negotiating body—a trend which is the outstanding characteristic of modern trade unionism—which has done more than anything else to iron out the differentials between rates of pay. As the officers of the modern giant union represent everybody, it is almost impossible for them to press the claims of one section of their members without, at the same time, making a similar claim for all the others. Indeed, the fact that the unions themselves have for so long taken their stand on the "human needs" basis of wages, makes it peculiarly difficult for them to make a distinction in the claims they put forward for different grades on the grounds of skill or other economic factors.

The general result of all this has been that in all wage disputes in the last few years there has been much preliminary talk of the need for wider differentials if the supply of skilled men is to be maintained, but this is almost invariably followed by an agreement which leaves them as they were or even which narrows them still further. It has become part of the agreement that assurances are given that the "wages structure" shall be completely overhauled when the heated atmosphere of the crisis has had time to cool down; but always, in practice, this proves too difficult to achieve before the next crisis looms up. For any alteration in structure necessarily means altering rates relatively and this, at once, rouses intense resentment and cries of "unfairness" on the part of those who would find their position relatively less favourable. It does not matter that the wage itself would not be reduced if its position in relation to others with which that grade has been accustomed to compare itself, is threatened. Like the pigs in "Animal Farm" who agreed that everybody was equal but pigs were more equal than anybody else, each group of workers is quite ready to agree to an overhaul in the wages structure provided its own position goes up and not down.

Relative positions do change, of course, as the result of many factors operating over a period, as has been shown to be the case with the relative position of the unskilled. But this has rather been the consequence of changes introduced for other reasons and was not a definite part of the objective. And once such changes have had time to establish themselves they become part of the normal pattern which must be maintained. Any conscious or deliberate effort to alter it is immediately labelled "unfair."

It is much easier to analyse these anomalies in wage negotiations than to make any suggestion to reduce them that has the slightest chance of being accepted. Nobody with any knowledge of industry or of human nature would pretend that a wage should, or could be a purely economic contract. Incomes play too important a part in social relationships for that and wage bargaining is immensely influenced by social attitudes of what is "right" and "proper." But, at the same time, it has to be remembered that wages have, in fact, certain economic functions to perform and that if too many difficulties are put in the way to prevent them from performing them, there is inevitably a heavy price to pay. So long as there is freedom for people to choose the occupation they go into instead of being directed to a job by authority, wages necessarily must act as one of the most potent, if not the most potent, influence in the decision. Wages are not simply the reward for past effort; they are also the signpost pointing to where more or less workers are needed. As our demands for goods constantly change their relative urgency and as new productive methods are invented, constant alterations in the numbers and types of workers in various processes and occupations are called for. Natural conservatism and dislike of changing one's way of living are strong enough forces in hindering these changes from taking place as rapidly as they should without creating others, and movements in wages do help by exerting a strong pull in one direction or away from another. If they are prevented from moving in relation to one another, their rigidity reinforces the lack of mobility which is, anyway, the product of the ordinary dislike of change, and industry becomes clamped into a set pattern. This, unfortunately, is just what an uncritical idea of "fair wages" is likely to bring about. We need to examine much more carefully what we mean by "fair" and why; and particularly whether the important contemporary development of the Welfare State has not made this moral element in wage settlement an anachronism.

Institute of Marine Engineers' Annual Report

THE Council of the Institute of Marine Engineers has issued its report for 1954: included among the events of special importance is the grant of a Supplemental Charter to the Institute by Her Majesty Queen Elizabeth and the Privy Council's assent to the adoption of new By-laws. The report records that the membership at the end of 1954 totalled 8421, representing an increase of 736 over the previous year's total, and goes on to indicate new activities started in various sections. A list is given of the papers read, discussed and published and also of the Institute awards, together with the results of examinations. The progress made with regard to the negotiations and the preliminary work on the preparation of the site for the construction of the Institute's new headquarters building is duly noted and the activities of the Sections at home and abroad are recorded in the form of individual reports. The report concludes with accounts of the work of those various research associations and Committees upon which the Institute is represented.

Institution of Naval Architects

ANNUAL SPRING MEETING

No. IV—(*Continued from page 566, April 22nd*)

THE meeting was continued on the afternoon of Tuesday with the reading of a paper with the title :

A HUNDRED YEARS OF LLOYD'S REGISTER SHIP RULES.

By J. M. MURRAY, M.B.E., B.Sc.

SYNOPSIS

This paper deals with Lloyd's Register Rules for the structure of ships since their rules for iron ships were introduced on April 12, 1855. It shows the development of the rules as the design of the structure of ships altered and as new materials were introduced. Important offshoots, such as the introduction of rules for machinery and electrical equipment are not included and many subsidiary developments are only briefly touched on, while no reference is made to the rules for trawlers and yachts. The paper is divided into two sections; one deals with the rules proper and the other contains observations on the underlying developments in ship design which have been reflected in the rules and the methods adopted by the Society to ensure that progress has not been retarded.

DISCUSSION

Mr. J. Hodgson : I think that it might be well to record that compliance with Lloyd's Rules is entirely voluntary and that the rules are actually controlled by a voluntary association of different sections of the whole shipping industry. This is a British idea which has been widely copied throughout the world. The rules, which must inspire general confidence, lay down minimum standards of strength which are universally acceptable, and must be based on the widest experience and available knowledge. One must remember that the early architects of the rules had little experience available to guide them and of necessity had to move forward cautiously, sometimes by trial and error. Even to-day, with improved knowledge and greater experience, we have frequently to do the same when progress demands new and untried types and methods of construction. With the advance in technical and scientific knowledge, theoretical principles have played a much greater part in the preparation of the rules, but it is probably true of ships more than of any other structures that the complete success of any new design cannot be fully assured except by service experience.

Records of service behaviour frequently disclose problems requiring urgent solution and indicate lines of profitable research. A particular problem is that of the brittle failure of steel, which is an old problem and a kindred institution devoted much of its *Transactions* between 1907 and 1913 to one such case without arriving at any satisfactory conclusion.

A considerable number of years elapsed before steel was considered entirely satisfactory for riveted ships, and to-day we are going through a similar phase in respect of the complete suitability of steel for all-welded ships. Adequate solutions will be found only by energetic co-operative effort and by realistic and objective thinking.

I would like to refer to the problem of post-war development in the modern high-speed cargo ship. It is no longer possible to prescribe a uniform standard of strength applicable to all types of cargo ships on the basis of dimensions only, and standard load distribution and speed have had to be introduced as a basis for correction factors.

Mr. J. Lenaghan : When looking through the paper I found great difficulty in casting my mind back to the rules that existed in the past thirty years. An excellent pictorial reference to associate with this paper is Mr. Campbell Holms' treatise on *Practical Shipbuilding*. Volume 2 of this treatise, with its diagrams and illustrations, shows details of the structural design of ships typical of a period fifty years ago and perhaps the most striking change is that which has taken place in framing. It is interesting to read in the paper that in 1867 the committee felt it necessary to impress on surveyors the need to satisfy themselves on the quality of the iron then in use, workmanship and good riveting. Instructions to surveyors continue to-day with a similar emphasis regarding the quality of steel, workmanship and sound welding.

The modern ship has presented many new problems, and recent changes in rules will go a long way towards taking care of these. The attention now given to the disposition of the cargo spaces and the introduction of a speed factor are in the right direction. I think that there are dangers, perhaps more psychological than physical, in providing too many safeguards with the intention of pin-pointing and overcoming faults in design. Rules provide for uniformity, but they can encourage a degree of single-mindedness, and in cramming too much into the rules there is the tendency for design staffs to overlook the advantages to be obtained in working out special cases for themselves. The more one knows of the details of the structure one designs, the better is the design and the sounder the basis from which the producers of rules must work.

The wartime standard cargo liner referred to in the paper may have had a good record as the result of a low total stress. The disposition of the engine space in these ships was not determined through consideration of stress values, but rather the operators' request for three good hatches forward and two aft of the main superstructure. One good feature now encouraged by the rules, although in fairness the rules never discouraged it, is the importance of structural continuity, particularly in longitudinal members. This feature in the naval designs gives the structure a sound and homogeneous look which designers on the merchant side could follow with advantage.

Professor A. M. Robb : I think of the " happy " days when you had a stereotyped job and submitted a 'midship section to Lloyd's and British Corporation, and you took the one which was the cheapest, a highly immoral thing. The British Corporation allowed us to do certain things, but Lloyd's would not. That is the sort of background against which I view this paper. I would like to see Mr. Turnbull give us 100 years of Lloyd's Register of Shipping Rules from the point of view of British Corporation, because I am intrigued by the incompleteness of the history given on the first page of the paper. The founding of the British Corporation was an attempt, as we all know, to get away from the tyranny of Lloyd's Register.

I would stress that of the three agencies, experience, experiment and calculation, experience is the most important, and would like to think that our theoretical knowledge is good enough to enable us to design things from first principles.

Mr. James Turnbull : I would say to Professor Robb that I still have the mantle of the British Corporation and I have also the mantle of Lloyd's Register. I have not shed either, because this was a uniting of the two societies. So that I am still a British Corporation Surveyor as well as a Lloyd's Surveyor, and have had the advantage of seeing both pictures quite intimately. It is natural that we should consider the work of the experts of the past in the light of our present knowledge, and it is easy to see the flaws in the basis for scantlings. Who could imagine anyone would consider that gross tonnage was a suitable basis for the scantlings of a ship ? Later we came on to numerals which were based on most unscientific grounds. That unscientific basis was put into the rules by men who had first-class knowledge of the then modern scientific information. Can Mr. Murray throw some light on this enigma ? I wonder if the generations of the future will look back on us and think of us as a few simple souls who could not find the obvious answers to the problems of to-day.

The most outstanding achievement in the period under consideration is the tremendous saving in hull weight, a reduction of as much as 50 per cent being effected in conjunction with other benefits, such as the removal of web frames and side stringers and a reduction of the number of pillars, resulting in the very clear holds of to-day. Whilst this evolution has not been as spectacular as that in other scientific fields, I think we should realise that it has had a tremendously favourable influence on the earning capacity of a ship.

Professor S. J. Palmer : I suggest that Fig. 2 of the paper may give the impression that the calculated stresses should follow the composite curve at the top of the graph. I assume that bending moments have been calculated for the 450ft ship with the gross tonnage kept constant by extending the superstructure at the ends, and that then with the assumption that the modulus is directly related to the beam and draught, the calculated stresses are as shown in full lines. Above $V/\sqrt{L}=0{\cdot}75$, because presumably, of slamming and other hydrodynamic forces which will increase with speed, the maximum calculated stress that Lloyd's are prepared to accept is shown by the dotted line.

Would the author confirm that he is not suggesting that the allowable stress should follow the limits given by the full curve up to $V/\sqrt{L}=0{\cdot}75$ and by the dotted line at speeds above this. If it can be relied upon at the higher speeds there would seem to be no reason why it should not be extended to lower speeds, flattening out as dynamic effects become small. It would, for example, be illogical to work to lower stresses in a ship whose $V/\sqrt{L}$ was $0{\cdot}6$ than those accepted for a ship whose $V/\sqrt{L}$ was $0{\cdot}75$, although that is what appears to be implied in the figure.

Mr. B. N. Baxter : Under the heading of " Research " the author mentions the growing practice of sending Surveyors to sea to observe the structural behaviour of ships. Do these observations include the measurements of hull strains and deflections ? The use of a statistical strain gauge, of the type used on the " Ocean Vulcan " trials, would be very advantageous in this connection. Can the author please tell me of any research work that is being done dealing with the questions of hull or local vibration ?

In the conclusions the author suggests that there may have been occasions on which the rules lagged behind progress. He has, I think, given an example in the present paper

showing how far they look ahead. The table in Appendix IV shows that the average speed of dry cargo ships has increased by 1½ knots in twenty-five years. This represents an increase from 0·612 to 0·683 in the $V/\sqrt{L}$ value for a 450ft ship. In Fig. 2 the curve of total stress is plotted on a base of $V/\sqrt{L}$ varying from 0·60 to 0·90, i.e. speeds of 12·73 to 19·09 knots. If it is assumed that the rate of increase in average speed remains constant then this diagram will still be useful for nearly another 100 years.

Mr. Bates: Some of the casualties sustained by the American fabricated ships and more recently by British-built ships, have shown that the undoubted benefits of the (welded) fabricated ship have introduced problems, both metallurgical and physical. Whilst appreciating the necessity to make only limited reference to many of the "so-called off-shoots of Lloyd's Rules," I feel there is one that must be mentioned and that is the subject of non-destructive examination. So far as I am aware, whilst Lloyd's welcome non-destructive examination, their rules do not make it mandatory. Again, whilst Lloyd's have a system of approving constructors' radiographers and of sending some of their own surveyors to a course on radiography, unless this non-destructive examination is done by a specialist of an independent organisation, and the interpretation is done by personnel who are doing it every day, the full advantage of any non-destructive examination is not gained.

Ships are frequently docked, overhauled and surveyed; surely if some measure of non-destructive examination at highly stressed zones were instituted during these survey periods it might be possible to repair small cracks before they propagate into major catastrophes. I feel that the limited costs of such non-destructive examination would adequately be offset by the possible failures they may prevent.

Mr. K. C. Barnaby: All designers of fast ships should join issue on one point. This is the assumption that speed necessarily increases the bending stresses as shown by Fig. 2. If we take a suitable block coefficient for the speed length ratio, such as that indicated by the well-known Alexander formula, and plot on a base of descending coefficients, we get a curve precisely similar to Fig. 2. It seems more correct to plot the results of a purely static calculation on a static and not on a dynamic base.

Against this, it may be argued that Mr. E. L. Champness showed in his 1922 paper that block coefficient had practically no effect on bending moments as measured by the conventional approximation of displacement multiplied by length and divided by 35. Why this difference between 1922 and 1955? The most acceptable reasons seem (1) Modern tank research has led to fuller 'midship sections and finer ends on fast ships, thus concentrating buoyancy amidships and increasing the hogging moment. (2) Relatively light crew spaces have been moved from forecastle and poop to amidships and the vacated spaces utilised for heavier cargo.

The revised Lloyd's Rules cater adequately for (2), that is for heavy weights on fine ends. The revision is perhaps a little overdue, for in 1866, Mr. John Grantham called attention to what he termed "the pernicious practice by which all science is set at naught of unduly loading the ends of long and fine ships." As regards (1), the concentration of buoyancy amidships, a true criterion would be the difference of the buoyancy and weight moments in either the fore or aft bodies about the L.C.B. This ought to include both hull and cargo weight, so it would be difficult to devise a simple formula to measure this difference. In lieu, Lloyd's have adopted the highly undesirable expedient of putting a penalty on speed. This masks the real trouble, and imposes an arbitrary and empirical penalty that may, or may not be needed. Thus, at considerably higher speeds than those shown in Fig. 2, it becomes desirable to increase the block coefficient and this tends to reduce the "eccentricity of loading," as the author terms it. There should then be a bonus and not a penalty on higher speeds. In this respect, an improvement would be effected if the penalty was based on fining the block coefficient and not on speed.

Professor E. V. Telfer: I feel that Mr. Murray has not lost many opportunities of turning the past critics of Lloyd's Register into probably its strongest defenders. For example, he actually suggests that John Scott Russell was a defender of Lloyd's Register. Probably his remarks at one time make it appear like that; but I do feel that if there were ever a critic of Lloyd's Register it was John Scott Russell. He was called a defender of Lloyd's Register because he was supposed to have said that the "Annette," a longitudinally framed ship, was built to show that Lloyd's were amenable to argument and that they would accept alternative arrangements. They did allow the knowledge and real wisdom of some of the leaders of the profession throughout the period of their existence to leave an impact on their own regulations, which I think is an excellent mechanism and is to be encouraged in all countries that attempt to build ships and whose men go down to the sea in ships. Whoever first advised the presentation of the British Corporation Rules well deserved mention in our professional history, and if that bit of history could be revealed it should be included in the discussion of Mr. Murray's paper.

Mr. C. V. Manley: The use of iron for shipbuilding began in the 1830's and it extended into the twentieth century, and that seems to be a really long period. The iron ship rules were not reissued after 1894, but ships continued to be built to those rules, 595 iron ships being built to Lloyd's Register class from 1894 to 1911. As a pointer, there are in Lloyd's Register Book to-day 362 iron ships, of 127,500 tons gross, and still operating. Included among them is the "Hsintai," a two-decker, 168ft long, 480 tons gross, built in Leningrad in 1840, and now under the Chinese flag and still doing her job.

The author refers to the introduction in 1870 of the "100A" class, which was associated with the lower grades "90A," "80A," and so on, long since discontinued. It is of interest that there is still one ship in the Register Book, the oldest class there, "90A.1." She is of iron and was built in 1877 at North Shields and is named "Lizzie and Annie."

Mr. Murray, replying to the discussion, said:

Probably the explanation I have given of Fig. 2 is not very clear, but the full line is what might be called the natural stress for the ship. In other words, if you have a ship with a $V/\sqrt{L}$ of about 0·60 you will find that in the homogeneous condition the natural stress is about 8·2 tons per square inch. When you get to a $V/\sqrt{L}$ of 0·80 you have a different ship altogether; you have probably a long poop and a long forecastle. Therefore, Professor Palmer made a very important point. The full line is the natural stress and the dotted line is the permissible stress, and I think it is proper, as suggested, that the dotted line should be continued to the right of the diagram.

As long as there is competition in classification there is bound to be a lowering of standards, and the fusion of the British Corporation and Lloyd's Register is one of the best things that ever happened for British shipbuilders from the point of view of safety.

The problem of non-destructive examination was mentioned by Mr. Bates. He will find that in about three months' time there will be an alteration in the rules which will more or less meet his point.

Mr. Lenaghan made an important point when he said that not enough calculations are done in shipyards. I am sure that Lloyd's Register would welcome the shipyards doing calculations rather than just grousing because there is red ink on the plan!

The meeting in the afternoon of Tuesday, April 5th, was continued under the chairmanship of Sir Charles S. Lillicrap, with a paper entitled:—

FORTY YEARS OF CHANGE AT PORTSMOUTH DOCKYARD WITH SOME NOTES ON DOCKYARD ORGANISATION.

By Ivor E. King, C.B.E., R.C.N.C.

Summary

The paper provides a general appreciation of the principal changes which have affected the production activities at Portsmouth Dockyard during the past forty years. It includes a brief outline of the general organisation of a dockyard, together with comments on present-day problems, most of which are common to some commercial yards, particularly those engaged on naval work. The period covered embraces both World Wars and the paper examines those factors which have operated continuously in changing the pattern of the yard. These are given as the increasing complexity, congestion and rate of change of ship installations, the changing pattern of the navy, the introduction of new shipbuilding materials and processes, and the changes in personnel relations and labour problems.

Discussion

Admiral of the Fleet Lord Fraser of North Cape: The paper shows that our constructors do not just live in the present, but have their eyes glued to the future. I would like to raise three points. When I read the other day that the "Venus" dragged her anchor and went ashore at Plymouth I remembered that Sir Stanley Goodall started experiments into the holding power of anchors, and I have always wondered whether he got any value out of them. Secondly, Mr. King refers to bottom compositions, and I remember that the Americans claimed that their ships could run for two years without going into dock to have their bottoms cleaned. I am wondering whether we have made any progress in that respect. Thirdly, I remember the exasperating delays in putting one ship after another into dock because we had to adjust the blocks. I was hoping Mr. King would say that he had a press button in his office whereby the blocks would adjust themselves, so that, when one ship came out of a dock, another would go in on the next tide. That is perhaps a little Utopian, but any gain in that direction would increase the value of our docks.

Vice-Admiral J. S. C. Salter: I find it interesting to compare the work in hand in Portsmouth Dockyard in 1914 with what is going on to-day. Then, one battleship had just been completed, one was fitting out, one was on the stocks, and a number of other ships were undergoing repairs, refits and docking. To-day we have one aircraft carrier undergoing complete conversion and rebuilding, a frigate almost ready to launch, and a number of ships undergoing refit, modernisation and repair. But the number of men in the Constructive and Engineering Departments

is virtually the same as then, and the number in the Electrical Department to-day is approximately three times what it was in 1914. So that we may expect to have considerable capacity available in the yard, but we have not, and the reason is the infinitely greater complexity of everything in the modern warship. Another facet is that far more attention is given to creature comfort on the mess decks ; there is the demand for greater living space, in addition to the demands for space for machinery and electronic gear which themselves demand more men to maintain and operate them.

The author has quoted from the speech made in Parliament in 1912 by the then First Lord, Sir Winston Churchill, in which he pointed out that from the date when the design of a battleship has been finally fixed she is obsolescent. That is infinitely more true to-day than it was then. In these days the building takes very much longer ; progress in nearly every sphere, and particularly in electronics, is far quicker and more drastic than it was then. The reintroduction of wooden ships, consequent on the magnetic mine, has meant that we have had to relearn much that we had forgotten.

My last point concerns the appointment of Superintendents of the dockyards. Some years ago there was talk in the House of Commons decrying the appointment of officers at the dockyards who had no previous dockyard experience. To-day all the Superintendents of the home dockyards have had previous experience of the work.

Mr. Norman M. Hunter : Some people question the efficiency and the speed of the work that can be carried out at the dockyards, but my experience is that they are efficient. The dockyards have always played a very useful part in the life of this country. They belong to us ; we provide the capital for them and the dividend we have had in the past has been the protection of our homes. They are also useful in the training of personnel who can help the commercial firms when contracts for naval work are placed with them.

From the information given in the paper the Portsmouth Dockyard appears to be well laid out. But what is going to happen to it now ? In these days, with aircraft growing bigger and more efficient and the weapons they carry growing more devastating, would it not be better to split it up into smaller units and distribute it all over the country? With regard to the organisation of the dockyard, I agree that it is advisable to have the general administration and control vested in the Admiral Superintendent, but it would probably lead to quicker decisions and more efficient arrangements if we had a general manager in control of all the other departments.

In the second section of the paper the author states that the " yardstick " which ultimately determines the overall amount of warship and other naval work of the four production departments of a dockyard is the annual sum of money voted in the Navy Estimates to cover the wages of the labour force to be employed. I think this yardstick should be very flexible. In my opinion that yardstick may lead to gross over-spending, for there might be an incentive to use up all the money in the period it covers lest you do not get so much next time.

The problem of maintaining the necessary numbers of craftsmen is a very serious one in the commercial shipyards as well as the dockyards. It is almost impossible to get boys nowadays where they have to work with their hands. That is a short-sighted policy, not only on the part of the boys coming from school, but also of their parents, who prefer that they should serve for a couple of years as messenger boys or in some such dead-end business rather than serve an apprenticeship to a craft which will stand for them all their lives. In the old days craftsmanship was looked up to, there was a dignity about it, but nobody wants to do any real hard graft to-day. If there is not a change I am afraid the country is about finished ; for we must have craftsmen or we cannot carry on.

There is reference also to incentive and merit schemes. I am of the opinion that the only really honest incentive scheme is straightforward piecework. Merit and payment-by-results schemes are simply a way to increase wages with no increase of work. There is mention of the Whitley organisation at the dockyards. The shipbuilding yards seem to have thoroughly representative works committees. During a very long managerial experience I have always found that to have a thoroughly representative works committee properly elected by the workmen, at which we can talk over their problems in a friendly way and tell them what we are aiming at, has led to very amicable relations.

Sir Stanley V. Goodall : For the greater part of the period covered by this paper I was serving in the department of the Director of Naval Construction at the Admiralty, and it is from that point of view that I intend to speak. The D.N.C. had no establishment in which he could conduct researches into the behaviour of structures until this last war. The result was that the researches that were carried out were conducted at the dockyards, and Portsmouth had the lion's share of that work. Money was always scarce and the Controllers of the Navy were not very enthusiastic when they saw a demand by the D.N.C. for money for experiments. But in spite of that limitation a good deal of research work was done.

In connection with the research work undertaken at Portsmouth I want to correct Mr. King's statement that experiments and application of welding technique and design for warships were sponsored and fostered very early in the post-World War I period. They were commenced during that war ; I think the first tests were carried out in 1917 and they constituted a record which was regarded as something like Holy Writ by those who foresaw a great future for the application of electric arc welding to shipbuilding. Those tests were referred to both in this country and in the United States as the " Portsmouth Tests."

The author refers to the amount of experimental work which was undertaken in association with the naval departments at Portsmouth, but apart from the material results that accrued from such tests there was another result and it was that work of this nature brought the design, the dockyard and the production branches of the Royal Corps of Naval Constructors into close touch with each other so that they appreciated the problems of each other and they all helped towards the solution of those problems.

Rear-Admiral J. E. Cooke : The Engineering Department suffers a handicap in that way because in the Royal Dockyards we do not, except in certain cases, build machinery, and we do not see the results of that machinery and what is required to repair it until some years later ; so that we have to think ahead and endeavour to put into the yard the plant and equipment we shall require. One advance at the dockyards is the use of the " marine railway " for getting the shafts in and out of ships.

Captain H. P. Rumble (United States Navy) : There has been reference to a rumour that the United States Navy dry-dock their ships at intervals of two years, instead of annually, as is done here. I can verify that that is not an idle rumour, but is true. In general our ships are brought into a dockyard every two years for a refit, and they do not go into dry dock in between those refits except for emergencies. There are many points of similarity between the problems in our country and yours. I was particularly interested in the references made to labour relations and to the committees that you have, because I realise that they are very important and that we do not get anything done without the willing efforts of all the people concerned and without getting together with them ; in my opinion that is a very important function of all the management levels of every organisation.

Mr. W. R. N. Hughes : What Mr. King has said about organisation and number of workpeople employed at Portsmouth applies equally at Devonport. But there is one major difference which has arisen only during the last few years, and that is concerned with the ability to enter adult workpeople and apprentices. The disturbing net wastage of craftsmen at Portsmouth is not nearly so serious in Devonport, since the south-west of England is rather lacking in engineering industries. There are certain key trades where entrants are few, but in the majority of crafts and grades we can enter all the men we wish, therefore it is possible that Devonport may actually grow bigger than Portsmouth before long.

Mr. B. N. Baxter : I would like to comment on the question of recruitment and training. I consider the Admiralty system of training to be thorough, and most democratic in the sense that all posts held by civilians, however high, are available to any apprentice who passes the requisite examination.

Nevertheless, the career prospects for the better type of apprentice appear to be poor. A few apprentices each year from the Constructive and Electrical Departments are awarded cadetships tenable at the Royal Naval College, Greenwich, but no such provision is made for the comparable apprentice in the Engineering Department. These, I assume, gain scholarships and awards, enabling them to obtain science degrees at various universities. After graduation they seek careers which are generally outside the Admiralty. This position also applies to a large extent to the apprentices of other departments who narrowly miss obtaining a cadetship. I am sure that many of them would return to the Admiralty if the career prospects were enhanced and some recognition taken of the fact that they had obtained higher qualifications.

One other aspect of the dissatisfaction with Admiralty service could possibly be partially remedied if attempts were made to ensure that all Admiralty apprentices who wished to do so could join the Royal Navy for their National Service. This would not only give them a very good insight to the end product of their skills, but would also give a sense of continuity to their service.

Mr. W. A. D. Forbes : In the limited time available I will just mention that I had intended to suggest that a joint productivity team should be sent to U.S.A., consisting of experienced dockyard officers, representatives of the shipbuilding and repairs industry, and the British Shipbuilding Research Association, because I feel the time has arrived when we should mechanise our dockyards to a far greater extent than now.

(*To be continued*)

British Industries Fair

No. I

THE thirty-fourth British Industries Fair will be opened at Castle Bromwich, Birmingham and Olympia, London, on Monday next, May 2nd, and it will be open daily until Friday, May 13th. As in previous years, the engineering section of the Fair is situated at Castle Bromwich.

Many of the exhibits of engineering interest have already been described in the columns of THE ENGINEER or shown in previous exhibitions, and will be familiar to our readers. We have, however, prepared from information given by some exhibitors the following descriptions of a selection of equipment of interest which is being shown at Birmingham for the first time.

W. CANNING AND CO., LTD.

The main working exhibit shown by W. Canning and Co., Ltd., of Great Hampton Street, Birmingham, 18, is to be a development of the firm's "Rotamatic" plating plant. In this plant the components to be plated are carried round a tank on a continuous circuit at a constant speed, which is predetermined to allow the necessary time for a specified thickness of metal to be deposited. In the new plant a drive is fitted to impart what is termed a "Pilgrim Step" movement of the components.

With the drive the work being plated travels forwards about 2ft and then moves back about 1ft—thus, although a 3ft movement has been effected, the work has actually advanced 1ft along the tank. This sequence of movements takes place in the same period of time hitherto required for 1ft of travel in the normal plant circuits. The new form of drive is stated to be advantageous in producing quality plating. One of the new plants is illustrated in Fig. 1.

An improved design of the firm's centreless polishing machine to be shown is suitable for polishing rods or tubes up to 6ft long. This machine has an adjustable rate of feed and foot control for quick work release from the polishing mop. A number of attachments are available which, when used in conjunction with shaped feed wheels, enables a variety of articles such as hubs, lids, bushings, cycle rims, &c., to be polished.

H.E.C. COMPRESSORS AND ENGINES, LTD.

Portable and stationary single-stage air compressors arranged for motor, engine and pulley drive with capacities ranging from 2 to 21 cubic feet per minute are made by H.E.C. Compressors and Engines, Ltd., Stechford, Birmingham, and representative models of these machines are shown on the firm's stand. A new machine recently introduced by the company is a small mobile set driven by a Lister 3½ h.p. diesel engine.

This small mobile compressor has a displacement of 16 cubic feet of free air per minute with a maximum pressure of 100 lb per square inch. It is particularly intended for use where small quantities of compressed air are required for such tools as chipping hammers, scaling hammers, &c.

The engine drives the compressor through vee belts and the two units are mounted on a common welded steel platform with an air receiver 18in long by 12in diameter. The chassis is mounted at the rear on an axle fitted with pneumatic-tyred wheels and at the front a castor steering wheel. A pneumatic unloading control device is fitted and the usual safety valve, pressure gauge, &c.

G. R. TURNER, LTD.

The exhibit to be shown by G. R. Turner, Ltd., Langley Mill, Notts, is a 350 tons per hour conveyor/elevator, which can negotiate horizontal bends down to 9ft radius (measured from the conveyor centre line), and vertical bends down to 8ft. Powered by two 45 h.p. motors in tandem, it has a speed of 200ft per minute, and it is stated that in the absence of vertical lift 700 to 750 yards can be covered without a boost drive.

The principle of the design may be gathered from the accompanying illustration (Fig. 2), which shows the underside of a number of the links from which the conveyor belt is constructed. As may be seen, two stiffeners are welded to each bucket, in such a manner that the stiffeners of each pair of buckets form a rhomb. The two buckets are linked by the horizontal axles of the supporting wheels, so that vertical movement is possible at the hinge thus formed. Consecutive pairs are joined by vertical pins carrying guide wheels, thus allowing the pairs to negotiate horizontal bends. Overlapping portions of the buckets are cylindrical about the respective axes of rotation, so as to keep clearances small.

ELECTRICAL REMOTE CONTROL COMPANY, LTD.

An automatic, self-resetting, synchronous, process timer with a wide range of industrial application is being exhibited for the first time by the Electrical Remote Control Company, Ltd., Harlow New Town, Essex.

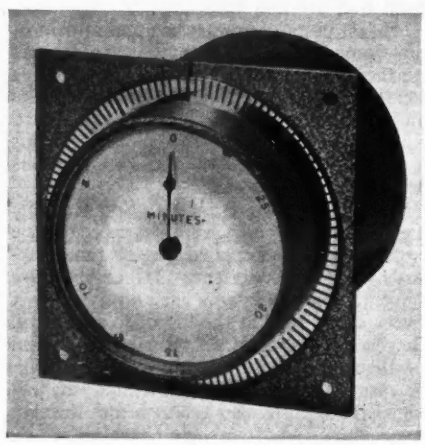


Fig. 3—Automatic self-setting synchronous process timer—Electrical Remote Control

This timer, known as the maker's "AB" type, consists essentially of a miniature synchronous motor, electromagnetic clutch with a timing disc, a time-setting mechanism which is controlled by turning the external bezel, a spring-loaded self-resetting mechanism, a time dial with pointer, contact piles and terminals. The whole of the mechanism is mounted in a cylindrical container 4⅝in diameter, supported by a front panel on the

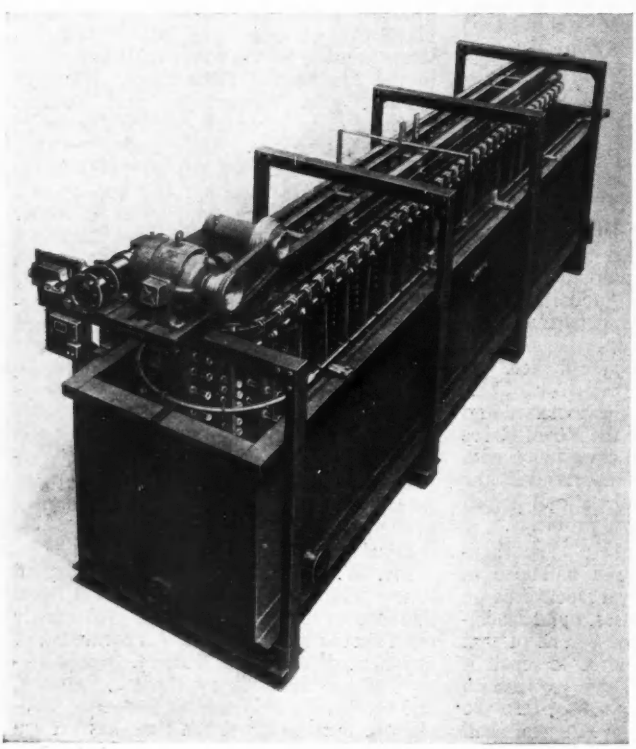


Fig. 1—Plating plant with "Pilgrim Step" drive—Canning

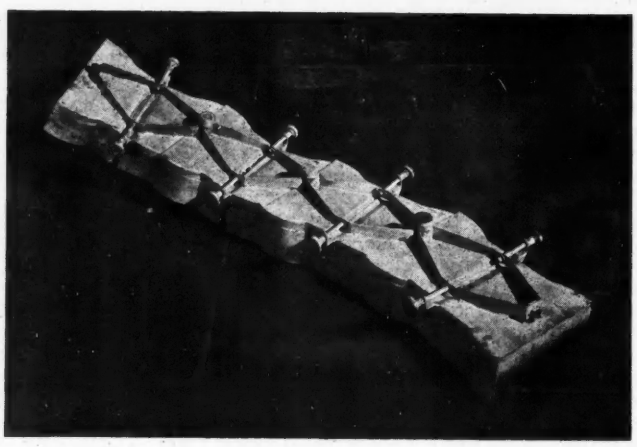


Fig. 2—Underside of conveyor/elevator showing method of linking buckets for negotiating sharp vertical and horizontal bends—G. R. Turner

face of which is mounted the time-setting dial.

The instrument (Fig. 3) can be supplied for a number of time ranges, and as a standard in different arrangements for times from 0 to 12 seconds to 0 to 7 days. Each time dial has 100 or 120 divisions and it is claimed that the time setting and repetition accuracy is better than $\frac{1}{2}$ per cent of the full-scale settings. Selection of time setting within the time range of the timer is done by turning of the bezel until the required time interval marked on the dial is set against zero marking on the panel. The bezel can be turned through full 360 deg. in either direction without danger of damaging the mechanism, and correction of time setting can be made while timing is in progress, provided that the pointer has not reached the zero marking.

Operation of the timer is initiated by closing the control circuit by operation of an external on-off switch, push button, limit switch, relay, &c. The instrument energises within one-tenth second, the pointer then moves from zero towards the time marking set. The visual indication of unexpired time is given by the moving pointer. The original time setting can always be read from the setting of the time dial, so that not only the unexpired, but also the expired time interval can be seen. At the end of the timing period, or when the voltage supply is disconnected, the timer resets itself automatically within half a second ready for the next operation. The readjustment of time setting by turning of the bezel is necessary only when the length of the timing period has to be altered.

Taylor and Challen, Ltd.

One of the three presses on the stand of Taylor and Challen, Ltd., Birmingham, is the double-crank machine of 120 tons capacity illustrated in Fig. 4. The press is driven by an 18 h.p. motor running at 960 r.p.m., and is shown tooled up for the production of a typical seamless component. It is built for single-action drawing and raising work, the bed being provided with air cushions and bolster plate. It has a built-up frame of tie-bar construction, the direct tensional stress being taken on four steel tie-bars, which are shrunk in position and tie the frame members rigidly together. The bed area is 76in from right to left and 36in from front to back.

The slide of the press has a stroke of 8in and is balanced by air cylinders, special safety gear being incorporated to prevent accidental fall of the slide.

Also exhibited is an open-fronted inclinable press fitted with double roll feed gear. This machine is driven by a 3 h.p. motor running at 960 r.p.m., giving fifty strokes per minute through single gearing.

The feed mechanism gives a travel which is infinitely variable up to 5¼in by adjustment of a roller friction clutch, using a 2 : 1 gear ratio. Provision is made for the feed rolls automatically to release the strip when pilot punches are used in follow-on tools. The feed rolls can be released by a pedal when inserting strip and when required, an automatic gauging and timing mechanism can be fitted which ensures that a newly-inserted strip is fully fed from a predetermined position into the dies, and that no "half-blank" is cut in the front edge of the strip. The press is shown fitted with a coil carrier and a scrap winder and performing blanking and piercing operations on strip material.

Scottish Machine Tool Corporation, Ltd.

The press brake illustrated in Fig. 5 is a hydraulically operated machine of 100 tons capacity made by the Craig and Donald Press Division of the Scottish Machine Tool Corporation, Ltd. It is designed to handle a mild steel plate up to 10ft long and $\frac{3}{16}$in thick, and its moving slide has a stroke of 9in.

The machine is of all-steel construction with side housings and a moving slide of heavy rolled steel slabs. Its deep moving slide has openings to accommodate two hydraulic cylinders and bearing pads welded on the top and bottom of these openings transmit pressure from the hydraulic rams. Each of the hydraulic cylinders has main and return rams, and they are supported at the front by a plate bolted to both housings and at the rear by a steel beam fixed to the housings by fitted bolts. An "Electraulic" hydraulic system is used and solenoid-operated control valves are controlled by a foot switch.

Also on this firm's stand is a 150 tons capacity two-point press. This machine is of tie-rod construction with a four-piece frame and is driven by a 15 h.p. squirrel-cage motor through gearing and an eccentric shaft. Its slide has an 8in stroke and gives eighteen blows a minute. A 4 h.p. motor is used for slide adjustment purposes. The area of the steel bolster and that of the slide face is 72in from right to left and 36in from front to rear. The control buttons for running, inching and stopping the machine operate the heavy-duty pneumatic clutch and brake through a solenoid-operated air valve.

Monometer Manufacturing Company, Ltd.

At Birmingham, Monometer Manufacturing Company, Ltd., Savoy House, 115/116, Strand, London, W.C.2, is exhibiting a rotary, oil-fired melting furnace for iron and steel and non-ferrous metals. As may be seen from the first illustration (Fig. 7), the furnaces rotate on two machined tyres which run on motor-driven rollers. The shell is conical at both ends, the end towards the burner being spring-loaded to permit the lining to expand. Products of combustion escape through the flue at the opposite end, either directly to the chimney or after first passing through a metallic preheater which warms the burner draught to 200 deg. to 500 deg. Cent. The flue is retractable so as to allow the furnace to be charged from

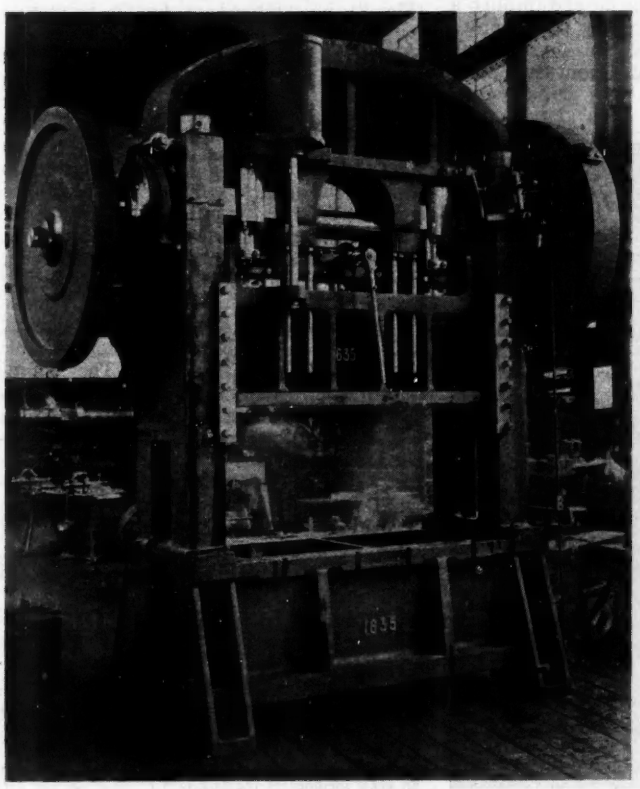


Fig. 4—120-ton capacity double-crank press—Taylor and Challen

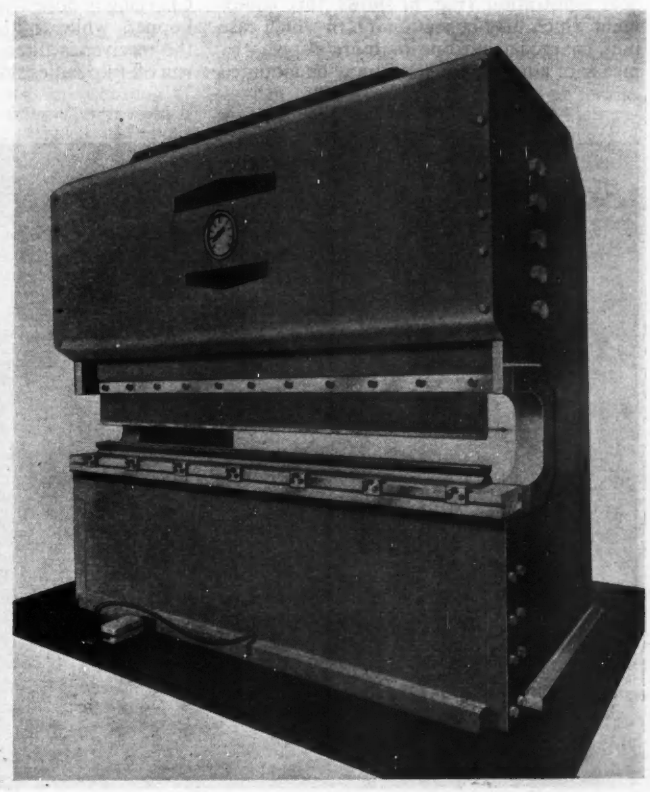


Fig. 5—100-ton capacity, all-steel, hydraulically operated press brake—Scottish Machine Tool

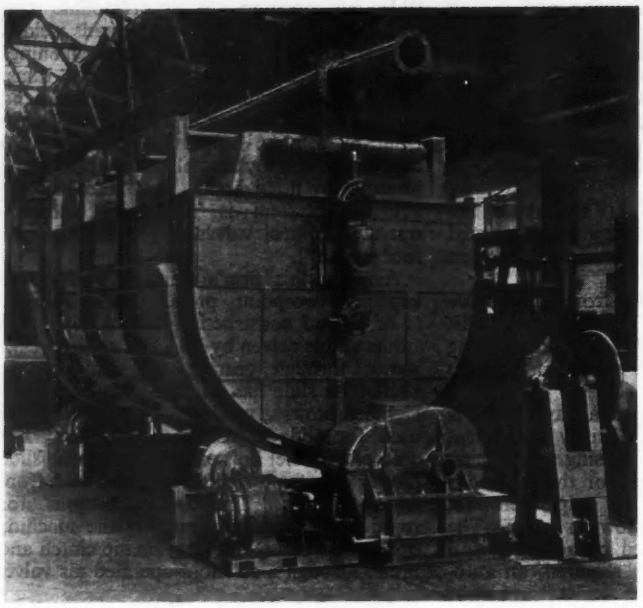


Fig. 6—Oil-fired hot-metal receiver for temperatures up to 1480 deg. Cent. Tilting is done electrically or by hand—Monometer

the flue end. For melting iron or steel a tubular recuperator is incorporated and oil-firing is employed, while for metals with a lower melting point, gas-firing is the alternative. The slow rotation has the effect of increasing the furnace efficiency by exposing the underside of the metal to portions of the lining which just previously had been heated by the flame. For melting iron and steel, the lining consists of rammed refractory; for non-ferrous metals high-grade firebrick is used.

Also shown by the same company is a mechanised, oil-fired hot metal receiver, intended for feeding ladles with slag-free molten iron at up to 1480 deg. Cent. Our next illustration (Fig. 6) shows this equipment which may be stationary, in which case it is charged from one or more cupolas by means of launders, or else it may be mounted on a bogie. The burner is situated at one end of the receiver and directs the flame directly on to the surface of the metal. A series of flues in the furnace arch permit the withdrawal of flue gases for preheating the incoming burner air. The fabricated, braced shell contains insulation lined with silica brick and is mounted on rollers which are supported in ball-bearing plummer blocks. Charging is done from the far end through a hopper, while in the periodic slag-removal the receiver is tilted backwards and the slag run off into ladles suspended from a monorail.

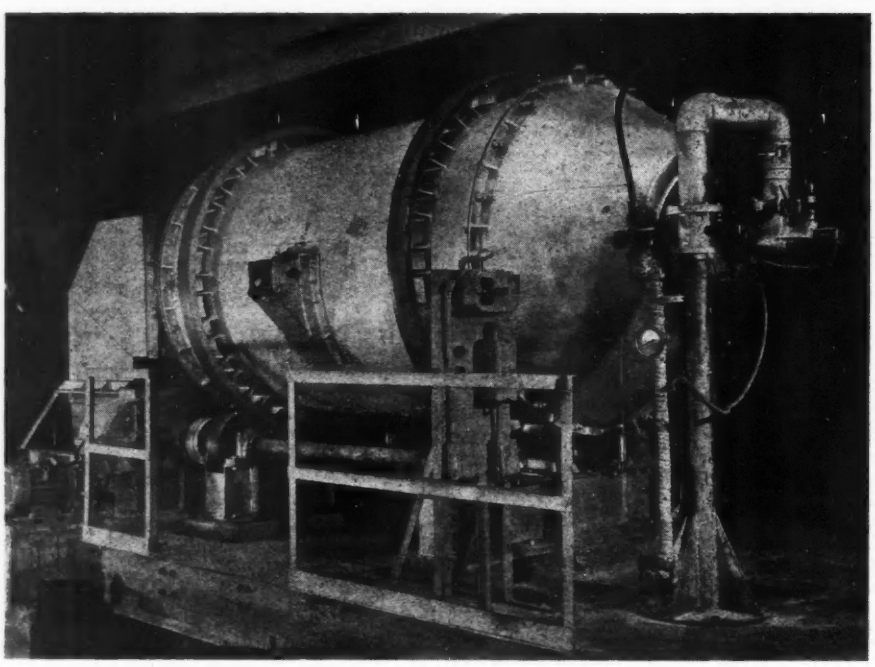


Fig. 7—Rotary furnace for iron, steel or non-ferrous metals. This mechanised oil-fired furnace is charged through the opening opposite the burner, which is fitted with a retractable flue—Monometer

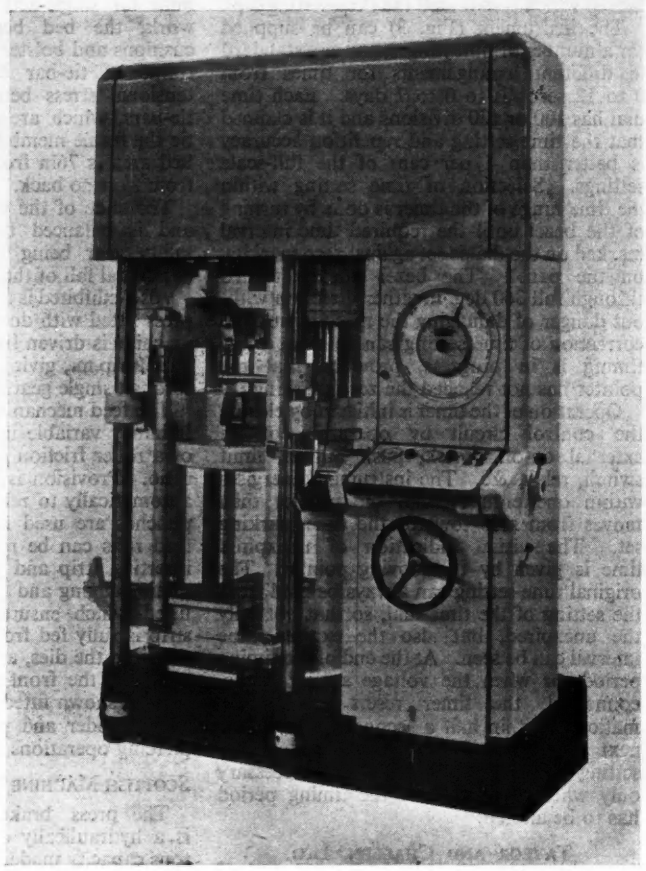


Fig. 8—Universal testing machine of 50 tons capacity, with desk-mounted controls. Loads are applied at preselected uniform speeds, and load-extension curves are automatically recorded—Samuel Denison

SAMUEL DENISON AND SON, LTD.

A 50-ton capacity, self-indicating, universal testing machine, the "Model T42B3" (Fig. 8), is exhibited at Castle Bromwich by Samuel Denison and Son, Ltd., Hunslet Foundry, Leeds, 10. As in earlier versions the load on the specimen is measured by means of a knife-edged weighing lever system. Without reduction in the testing space the height and width of the machine have been reduced and, as the illustration shows, the controls have been grouped together on a desk panel. For standard size specimens the 50-ton test range is available, but for smaller specimens sub-ranges can be used, with resultant increase in the reading accuracy. Many accessories are available for carrying out tests in tension, bending, 180 deg. cold bend, compression, double shear, and punching tests. The equipment includes the model "28 P.H." autographic load/extrusion recorder, which is operated from a high-magnification extensometer fixed to the specimen, and permits load-extension curves to be mapped automatically and right up to the point of fracture. A hydraulically controlled device, powered by a fractional horsepower electric motor, serves to apply the load at a preselected uniform rate.

(*To be continued*)

PRESENTATION TO KING'S COLLEGE.—At a recent luncheon in London, Professor S. J. Davies was presented with a set of the *Proceedings of the Diesel Engine Users Association* for the use of the Faculty of Engineering at King's College, London. These volumes of the *Proceedings* were the personal property of Mr. J. L. Chaloner, an early member of the D.E.U.A., who made the presentation. Professor Davies has been for several years Professor of Mechanical Engineering at "King's"; he is now Dean-Elect of the Royal Military College of Science, at Shrivenham.

Road Research in 1954

The activities of the Road Research Laboratory during last year are reviewed in the booklet "Road Research 1954," which has now been published by H.M. Stationery Office As is usual, the booklet contains an introductory report of the Road Research Board, followed by a more detailed report by the Director of Road Research. We print herewith abstracts from the Board's report.

DURING the past year we heard with satisfaction that a programme of new road construction had been drawn up. While it is generally recognised that this is still on far too modest a scale to meet traffic needs it does provide a welcome opportunity for the results of the work of the Road Research Organisation to be applied in practice. The amount of new construction that can be undertaken is strictly limited and it is our concern to ensure that full information is made available on costs of accidents, costs of traffic delays and costs of construction, usage of roads, traffic speeds and other factors which serve to guide decisions of priority. The Laboratory is working to these ends.

We particularly welcome the action of the Ministry of Transport and Civil Aviation in allowing a number of new sections of road to be used by the Laboratory for experimental purposes. These include the Ashford By-pass on A.20 in Kent, which will yield comparative data on flexible and concrete roads, including the use of soil-cement, and the Loughton By-pass on A.5 in Buckinghamshire, which will provide an opportunity for carrying out an experiment on flexible road construction. Trial lengths will also be laid to investigate how far the performance of concrete roads may be improved by using concrete of high flexural strength. We note also that the experiment on a clay subgrade, for which we have pressed for many years, is expected to be begun within the next year on A.1 at Alconbury Hill (Huntingdonshire).

The Ministry of Transport and Civil Aviation has arranged for the conduct of extensive "specification trials." Six trial lengths have been laid this year. Trials of this kind will make it possible to pass more quickly from the stage where the results of road experiments first become available and tentative specifications are drawn up to one where practice is sufficiently proved for widespread adoption ; they should, thus, enable the benefits of research to be reaped much sooner.

We have been informed that the site at Crowthorne, Berkshire, chosen for the new Road Research Laboratory has now been taken over by the Ministry of Works from the Forestry Commission. It is intended first to complete a testing track and a paved central area for traffic experiments and later to proceed with the Laboratory buildings.

The Traffic Problem.—Figures obtained from traffic counts given in the report show that in 1954 traffic in England had increased by 13 per cent as compared with the figures for 1952. If the current rate of increase in vehicle registrations continues the number of vehicles on the road in 1963 will be about double the present number. If this rate becomes greater, as it may well do in view of the projected expansion of the motor industry, the number of vehicles on the roads may be doubled at an even earlier date.

Recent figures for road accidents have shown a disturbing upward trend in line with the increases in traffic density. In spite of a growing awareness of the need for road improvements we are perturbed at the absence as yet of a comprehensive programme that would provide for future traffic and the safety of the road user.

The similar situation in the U.S.A. is being met with a new 100,000 million dollar highway plan ; no comparable expenditure may be possible in this country, but it seems difficult to escape the conclusion that the increasing gravity of the position will compel further funds to be made available for improvement in road construction and accident prevention. The most effective way of using resources will only be found by determining how much each type of road improvement will reduce accidents and increase the flow of traffic. In this connection we welcome the assistance which has been offered by the County Surveyors' Society and the Institution of Municipal Engineers, whose members have undertaken to furnish the Laboratory with information from their records regarding the influence of changes in road layout on the occurrence of accidents. This information should prove a valuable supplement to the work of the Laboratory in this field.

The planning of traffic facilities should be based on data about journeys people wish to make. We are pleased to report that the Social Survey and the British Transport Commission have co-operated with the Laboratory in a survey of this kind in London and that Birmingham University and the Laboratory are collaborating in a survey related to the economic value of motorways. We await the results with interest.

A further requirement in planning traffic facilities is the knowledge of the cost of traffic operation under various conditions. To this end the Laboratory is collecting information about the effect of road layout and traffic control on speeds and delays ; data are available about the effect of road curvature and gradients on speed and on the delays to be expected at traffic signals for different conditions of traffic ; this latter information indicates the settings of signals required under certain conditions to reduce delays to a minimum.

Accidents.—We have already referred to our grave concern at the worsening position as regards road accidents. Several matters mentioned in the Director's progress report may usefully be emphasised here as indications of ways in which accidents may be reduced. Thus, in some instances, better lighting for groups of streets reduced accidents at night by some 30 per cent : surface dressing or resurfacing nine sites on which there had been an exceptional number of accidents involving skidding resulted in their entire elimination in the following twelve months. An analysis of casualties on a group of dual-carriageway roads showed that twenty-five of the fifty-seven people killed were pedestrians and eight were pedal cyclists—an indication of the value of special motorways from which cyclists and pedestrians are excluded. In about four of every five accidents to cyclists another vehicle was involved, this again indicates the value of segregating types of vehicles.

Further evidence of the value of such segregation is provided by studies of the numbers of accidents involving people being injured on different types of road. For comparison, these figures are expressed as rates per million vehicle miles and may be termed "accident rates" for simplicity. These rates range from twenty for main roads carrying heavy traffic and passing through busy shopping centres where there are large numbers of pedestrians, to two for lightly trafficked rural roads ; roads in residential areas on the outskirts of towns show intermediate values. Motor roads with restricted access, dual carriageways and fly-over junctions, even though they carry very heavy traffic, have much lower "accident rates" than even lightly trafficked rural roads ; "accident rates" for such roads in the U.S.A. and in Germany range between 0·4 and 1·2.

Other items from the Laboratory's work have been selected for mention below as being of special importance or interest.

Toughened Glass.—Toughened glass windscreens have the merit that in an accident they shatter into small rounded fragments that do not usually cause serious cuts ; their drawback is that they sometimes break up into a mosaic of particles which is practically opaque, a result highly dangerous for the driver of a car travelling at high speed. The manufacturers have now produced experimental glasses giving, when fractured, mosaics of larger particles. Tests made by the Laboratory on a track showed that, when the windscreen of a car travelling at speeds up to 60 m.p.h. was shattered, it could be safely driven round obstacles, provided the count of the particles in the shattered screen did not exceed twenty-five to the square inch. These results have been brought to the notice of the British Standards Committee on Safety Glass, which is recommending an appropriate change in the present standard.

Vehicle Lighting.—A summary has now been published of the Laboratory's investigations on the design of vehicle headlights and the problem of dazzle. The investigations show that a great improvement in seeing at night could be attained by more accurate setting of vehicle headlights. Tests on cars chosen at random from those travelling on an arterial road showed that the headlights were badly set even in many almost-new cars. This suggested that they had left the makers' works in this condition. Motor manufacturers were informed ; some are installing test equipment.

Yellow Headlight Beams.—The Laboratory has investigated the distances at which various grey objects were first visible in white and in yellow light (*a*) of the same intensity, (*b*) from bulbs of the same wattage. The differences in recognition distances were so small as to be within the variation due to chance. The opinion held by many motorists that French yellow headlamps are less dazzling may be due to the fact that the higher power of the British lamp, particularly above the horizontal, gives advantage to the British car in France.

Protective Helmets.—We are glad to see that motoring organisations are now equipping their motor-cycle patrols with protective helmets. Studies of hospital records have shown that 60 per cent of head injuries are due to blows on the front, indicating that helmets should have the maximum protection in this region. The Laboratory investigations suggest that although the padding next to the head may be soft, the bulk of the protection should be provided by a layer of materials of about the compressibility of cork : the outer shell should be tough and not brittle and should be smooth enough to slide easily over a road surface. The Laboratory is in close touch with manufacturers of protective helmets in matters concerned with their design.

Soil-Cement.—The popularity of soil-cement as a road base is steadily growing where conditions are suitable for its economic use : it has already been used by twenty-two local authorities for some 80 miles of housing estate roads and classified or other roads carrying through traffic. Some twenty-six local authorities are now equipped with trained staff and laboratories to carry out testing work for the control of soil-cement and other forms of construction.

Gravels.—In some parts of England gravel is widespread and cheap. With the help of the Ballast, Sand and Allied Trades Association a survey has been made of present-day production of single-sized gravels as aggregates for road construction and the Laboratory has subjected representative samples of gravel to a wide range of tests. The information obtained is set out in a recent publication ; the results of the survey formed the basis for the new British Standard for single-sized gravel aggregates.

Soil Compaction.—In 1945 the Laboratory began an extensive and systematic study of the performance of plant in compacting soil and the results of the first four years' work were summarised in technical paper No. 17, published in 1950. The results of later work on further types of special compaction plant have now been published as technical paper No. 33, *Further Studies in the Compaction of Soil and the Performance of Plant.*

Surface Water Drainage.—We have for some time been impressed by the need for further research into the design of surface water drainage systems. It is generally believed that present methods of design lead to drainage systems which are too large for the areas they will serve. A valuable beginning has been made in the design and installation of recording equipment and in the analysis of records of rates of rainfall and run-off at eight sites covering a variety of conditions. At the suggestion of the Ministry of Housing and Local Government, which is also keenly interested in this work, we

have set up a joint committee with them to assist in carrying out these investigations on an increased scale : the committee includes members of the staff of the Meteorological Office, the Hydraulics Research Station and the Water Pollution Research Laboratory.

Concrete.—A Road Note has been published giving recommendations for the design of concrete roads on representative soils for different traffic conditions : these recommendations are based on information gained from the Laboratory's road experiments, from examination of existing roads and from laboratory studies and tests.

Work in Scotland.—Further experiments have been carried out on the use of colliery shales and other local materials for road bases. The detailed recommendations for surface dressing put forward in Road Note No. 1 were largely based on experiments carried out in England. Experiments have been put in hand to see what modifications, if any, are required to meet the rather different climatic conditions in Scotland. The answering of technical inquiries is a growing feature of the work of the branch in Scotland. This is gratifying evidence of the branch's growing influence, but is disturbing in its effect on the progress of the main researches.

Colonial Road Problems.—We are pleased to learn that the proposal to allocate £50,000 from the Colonial Development and Welfare Fund for research on colonial road problems to be undertaken by the Laboratory has been favourably received by the Colonial Governments concerned. The plan is to spend this money over a period of two years ; as initial steps, accommodation for a new colonial road section is to be provided at Harmondsworth, an assistant to the colonial liaison officer is to be appointed, and staff is to be recruited, additional to the complement provided in the Department's five-year plan. A committee is being formed, with Dr. W. H. Glanville, the director of road research, as chairman, to advise the Secretary of State for the Colonies on colonial road research.

Remote Indication by Electromagnetic Transducers in Atomic Factories

A NEW electromagnetic transducer system, developed by Salford Electrical Instruments, Ltd., to give remote indication of pressure and mechanical displacement, has been applied to various processes in Great Britain's atomic factories. In particular, it has been successfully adapted to the gaseous diffusion process at Capenhurst, in which the more fissile uranium 235 isotope is extracted from the uranium 238 isotope.* This process involves the use of uranium hexafluoride at a temperature of about 75 deg. Cent., and the transducer has the advantage that it enables direct and precise measurements to be made on this highly corrosive material.

Gaseous Diffusion Process for Extracting Uranium 235

The gaseous diffusion technique of extracting the uranium 235 isotope depends on the fact that, when a gas diffuses through tiny holes in a membrane, the lighter molecules pass through faster than the heavier ones ; consequently the gas on the far side of the membrane initially contains more than its natural proportion of light molecules. If, at this stage, the diffused gas is pumped away, the fraction removed will, therefore, be richer in light molecules than the fraction remaining behind.

The effect is very small and gets smaller as the masses become more nearly equal until, for molecules of a gas containing atoms as nearly alike, and as heavy, as uranium 235 and 238 (they differ by about 1 per cent) it is very small indeed. But the enrichment can be increased nearly to 100 per cent by pumping the slightly enriched gas through many successive membranes.†

The first requirement for this process was a gaseous compound of uranium and the compound used for this purpose was uranium hexafluoride (known as Hex), which is gaseous at temperatures as low as 60 deg. Cent. This compound has the advantage that fluorine, the second constituent, possesses only one isotope, so that the course of the diffusion is determined solely by the uranium and not by the fluorine. On the other hand, uranium hexafluoride is highly corrosive, solidifies when the temperature drops below about 38 deg. Cent. and reacts readily with a great many substances, including water, to form solid compounds, which would slow down or stop the whole process if they were allowed to build up.

All the equipment used in this process must, therefore, be highly resistant to chemical attack. At the same time the gas pressures in the various sections of the plant have to be closely controlled, and the electromagnetic transducer has proved particularly useful for this, since, with its aid, the uranium hexafluoride gas is prevented from coming into contact with the recording or indicating instruments. In addition, the pressures are registered directly on instruments which can be located a thousand yards or more from the measuring head. A view of a control deck at Capenhurst is shown in Fig. 1.

Operation of the Transducer

The S.E.I. electromagnetic transducer system comprises an electromagnetic measuring head and a recorder-controller or a special dynamometer moving-coil instrument. No electronic valves, barretters, rectifiers or magnetic amplifiers are used, and the equipment is independent of mains supply variation. In Fig. 3 we show a cross-section of the transducer measuring head

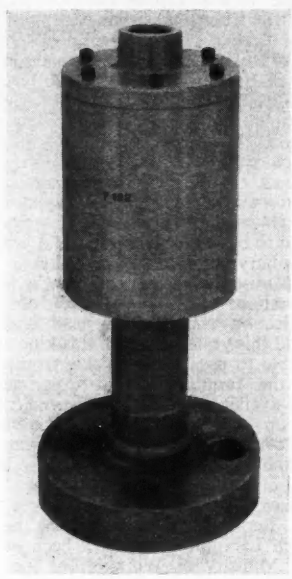


Fig. 2—The S.E.I. transducer as used in the atomic factories for supervising the gaseous diffusion of uranium hexafluoride. The electromagnetic measuring head shown here registers pressure directly on an associated remote instrument

which consists essentially of a magnetic core mounted between two coils on a spring-loaded shaft. Any movement of the stylus on the end of this shaft displaces the magnetic core and causes a variation in the magnetic flux. The circuit is so arranged that the controller or indicating instrument then automatically adjusts itself so that this variation is balanced out. Mechanical displacements of less than 0·001in can be measured directly with this system.

A complete circuit is illustrated in Fig. 4. There are two coils on the iron core in the dynamometer instrument shown. The mains excited primary winding provides an a.c. field for the instrument and energises the secondary winding supplying a bridge circuit formed by resistors R_1 and R_2 and coils L_1 and L_2. The latter coils are differentially variable inductors in the transducer.

The bridge output voltage is substantially in phase with the meter field flux, whereas the induced voltage in the moving coil is in quadrature with the field flux. The induced voltage in the moving coil is proportional to its angular deflection with respect to the flux. When the pointer carried by the moving coil is in the correct position, the vector relationships are such that the resultant of the moving coil and bridge

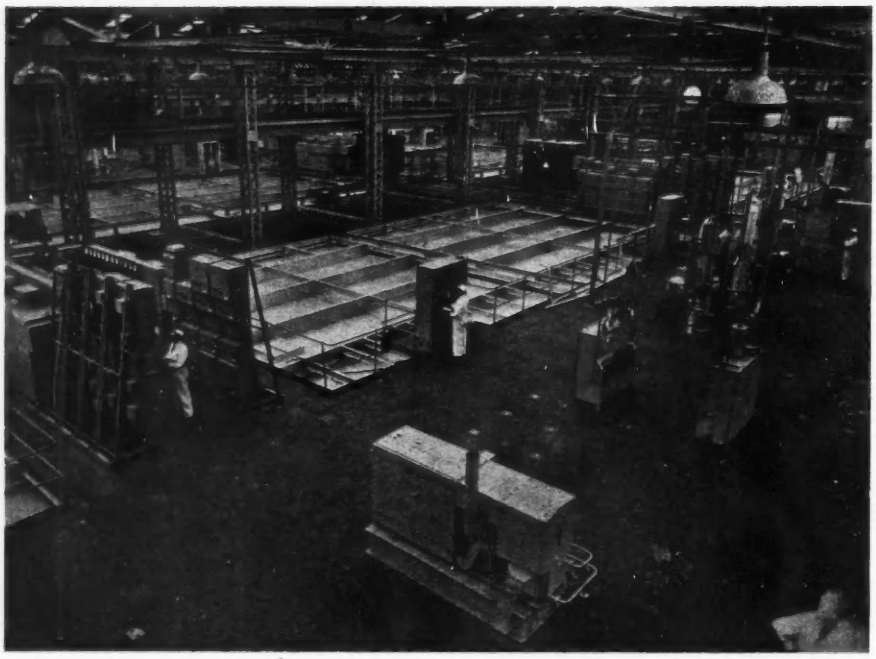


Fig. 1—Control deck at Capenhurst. Here the new S.E.I. electromagnetic transducer system for remote indication of pressure and mechanical displacement is used for supervising the gaseous diffusion process in which the uranium 235 isotope is extracted from the uranium 238 isotope

* Natural uranium metal contains about 0·7 per cent of the 235 isotope, the remainder being the 238 isotope.

† The technique is outlined in *Britain's Atomic Factories* published by H.M.S.O.

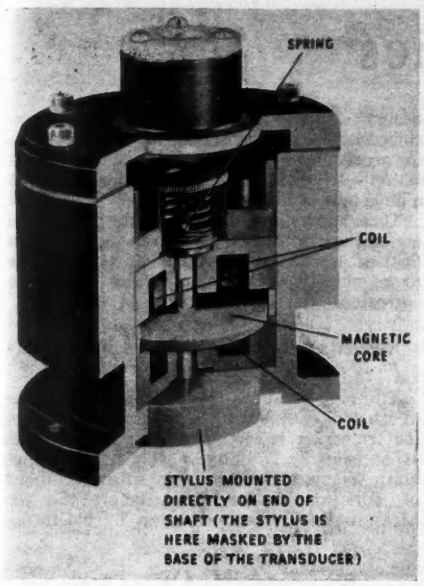

SPRING
COIL
MAGNETIC CORE
COIL
STYLUS MOUNTED DIRECTLY ON END OF SHAFT (THE STYLUS IS HERE MASKED BY THE BASE OF THE TRANSDUCER)

Fig. 3—Cut-away section of the transducer measuring head. The magnetic core consists of a flat disc mounted between two coils on a spring-loaded shaft. Movement of the stylus on the end of this shaft displaces the disc, causing a variation in the magnetic flux which is reproduced as a direct measurement of the displacement on an associated measuring instrument

output voltage circulates a current through the moving coil in quadrature with the field flux. The electrical torque on the system is then zero and, since the system is not spring controlled, the pointer will take up, or remain in, the zero torque position. If the pointer and moving coil are in some position other than the correct one, this quadrature relationship will not be obtained, and the in-phase component of the moving coil current will interact with the field flux to produce a torque in such a direction as to restore the balance condition.

Since the system is dependent only on vector relationships, it is substantially independent of supply voltage and frequency variations.

The basic transducer, as described above, is readily converted into a pressure-measuring device by incorporating a suitable pressure responsive element such as a diaphragm to actuate the armature. In this form instruments can be provided for measuring pressures from a few inches of water gauge to over 200 lb per square inch. Used in conjunction with a Bourdon tube instead of a diaphragm, equipment can be provided which will measure pressures up to 10,000 lb per square inch.

Since transducers used with uranium hexafluoride have to operate at 75 deg. Cent., they are oven-calibrated at this temperature at the works, although the standard models do not change by more than 1 per cent of the full scale reading over a temperature range from 0 deg. to 70 deg. Cent.

The straightforward direct pressure transducer, as described above, can be adapted to suit various applications. For example, if it is necessary to avoid the fluid or gas under examination coming directly in contact with the measuring head, either a "masking" diaphragm or an isolator unit can be used.

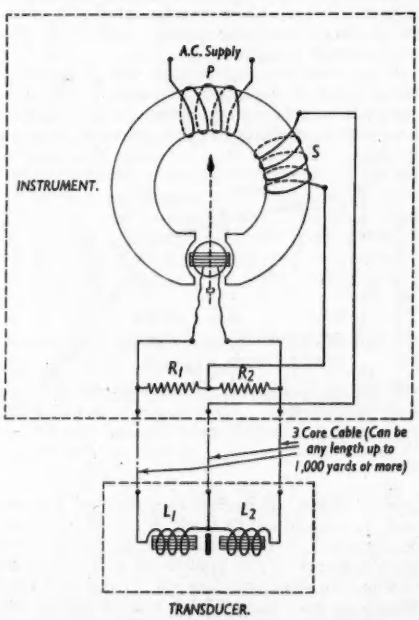


Fig. 4—Circuit diagram showing the operation of the S.E.I. electromagnetic transducer system

Tractor and Cultivator Development

AT last year's Royal Show, the prototype of a 51 h.p. crawler tractor, known as the "Platypus PD4," was exhibited by Rotary Hoes, Ltd., West Horndon, Essex. This tractor is now going into production at the firm's new works at Basildon, Essex, and last week we saw it in operation with a five-furrow plough. The tractor has an overall width of 5ft 8in, weighs approximately 5 tons, and exerts a drawbar pull of 12,000 lb. It is fitted with a Perkins "L4" diesel engine designed to give 51 b.h.p. at 1600 r.p.m. The power is transmitted through a hand-operated single plate clutch, the totally enclosed gearbox providing for six forward speeds between 1·1 and 4·5 m.p.h. and two reverse speeds of 3·6 and 1·9 m.p.h. The steel track frames are hinged about pivot axles forward of the final drive housing. Each frame has four lower track rollers, one top roller and one front idler wheel mounted in a cast steel fork, and has a spring recoil assembly and slide brackets. There is double-cranked torsion beam suspension which provides articulated anchorage to each frame. Each track consists of thirty-one one-piece links. There are alternative widths of 16in or 24in for the track plates, the ground contact area with the former being 2240 square inches and with the latter 3360 square inches. The gauge of the tractor from centre to centre of tracks is 4ft 4in, and the ground clearance is 13in. The tractor is equipped with a six-spline power take-off shaft operating at speeds of 750 r.p.m. or 550 r.p.m. The accompanying illustration shows the tractor at work with a five-furrow trailed plough.

Another recent development of Rotary Hoes, Ltd., is concerned with the "Bulldog" and "Yeoman" rotary cultivators, which it introduced about a year ago. These machines were described in our issue of July 9, 1954. The "Rotavator" principle, it may be recalled, is based on the rotary movement in the ground of "L"-shaped hoe blades. Both the "Bulldog" and the "Yeoman" are handlebar controlled machines, suitable for garden and small-holding work, the former having a cultivating width of 10in and the latter a width of 15in. The "Bulldog" is driven by a 1½ b.h.p. petrol engine and the "Yeoman" by a 4½ b.h.p. petrol engine. In the case of both machines, the "Rotavator" can be easily removed to permit the attachment of several other implements. In the case of the "Yeoman," which is the larger machine, the attachments now include a Gilbert Gilkes and Gordon self-priming pump capable of delivering 1200 gallons an hour. Another attachment is a power take-off pulley giving two speeds of 2150 r.p.m. and 1490 r.p.m.

Diesel-engined 51 b.h.p. crawler tractor operating a five-furrow plough. The tractor gives a drawbar pull of 12,000 lb

Diesel Engine Users Association Annual Luncheon

THE annual luncheon of the Diesel Engine Users Association was held on Thursday of last week at the Connaught Rooms, London, and was attended by over 200 members and guests with the president, Mr. F. J. Mayor, in the chair. After the loyal toast, Mr. Mayor proposed the toast of "Our Guests," and welcomed the presence of a number of past-presidents. In the course of his remarks, he commented upon the papers given during the year, thanked the authors, and went on to commend the hospitality of the firms visited by members of the Association. Rear Admiral (E.) D. J. Hoare, C.B., the principal guest, replied and proposed the toast of "The Association," the founding of which, he commented, took place in the same year of his first commission. The Admiral recalled his early experiences with diesel engines and his eventual appreciation of their usefulness, and went on to mention his early acquaintance with the Association and the value of its interest in research. Regarding the question of research he noted that although the value of diesel engine production was £50,000,000, the contribution to B.I.C.E.R.A. was only £25,000. Although the Association was run by the industry there was support by only twenty companies and the Government, and from this he concluded that the industry was not in favour of co-operative research. That, the Admiral felt, was a matter for regret since there was a need for research and development and he decried purely individual effort. Research associations, he continued, were a British idea now being copied abroad, and he was convinced that it was better for manufacturers to combine in order to make technical progress and produce new designs with which to meet the challenge of the gas turbine and also that of other countries in the markets abroad. The toast "Vote of Thanks to the President" was given by Mr. A. K. Bruce, who was in favour of presidents being diesel engine users, and went on to comment on the unfettered discussion of problems under Mr. Mayor, who, he said, was a practical man and a friend of technical progress.

Metallurgical Topics

Fretting Corrosion

THE damage undergone by a metal when its closely fitting surface of contact with another metal or non-metal is subjected to vibration causing relative slip between the two components is known as fretting corrosion. When one of the surfaces is glass (for example, chromium on glass), small glittering particles are visible at the position of damage, and the term corrosion cannot be applied. In fact, some authors (including I-Ming Feng*) prefer to use the term "fretting damage" rather than "fretting corrosion" in all circumstances. Press-fitted surfaces of steel are frequently difficult to separate, and when separated are found to be coated irregularly with rust-coloured debris. This may be accompanied by pitting. A recent contribution to the subject has been made by I-Ming Feng and H. H. Uhlig,† who have investigated the fretting corrosion of mild steel in air and in nitrogen. The extent of the damage was measured by the loss in weight of two mating cylindrical test specimens of 0·15 per cent carbon steel, 1in diameter and 1in long, subjected to a defined oscillatory slip. The prepared surfaces were clean and free from lubricant. The load was applied pneumatically. The environment was controlled by enclosing the test specimens in a stainless steel cell with a glass window and neoprene gaskets to ensure a gas-tight fit. Humidity of the air was a variable which required control. The loss of weight in moist air was only about 55 to 65 per cent of the loss of weight in dry air. Fretting corrosion was appreciably greater below atmospheric temperature than above (up to 150 deg. Cent.). Losses of weight at 0 deg. Cent. were 40 per cent higher than at 30 deg. Cent. and were nearly double the losses at 75 deg. Cent. This agrees with the practical observation that fretting corrosion is more severe in winter than in summer. The rate of fretting in air remained constant after an initial running-in period during which it was temporarily greater. As already stated, in moist air, and also in dry nitrogen, the losses in weight were much smaller. In one series of tests, for example, after 203,400 cycles the loss in dry nitrogen was only 1·9 mg, as compared with 10·7 mg in dry air. In the complete absence of slip there was no loss of weight. The loss of weight was greater, the greater the relative slip, the greater the pressure between the surfaces, and the lower the frequency for the same number of cycles (i.e. the greater the time of action). The frequency effect disappears in nitrogen, as shown by the following results for loss of weight of specimens subjected to 67,800 cycles at a pressure of 5300 lb per square inch, the slip in all cases being 0·0036in :—

Frequency, cycles per sec.	Loss of weight in mg. In dry air	In dry nitrogen
58	12	—
250	10	1·5
1250	5	1·5

Mechanism of Fretting Corrosion

Making use of these data and of much previous information, H. H. Uhlig‡ has formulated a theory of the mechanism of fretting corrosion. He started with the following list of characteristics of fretting corrosion that must be taken into account :—

(1) Fretting damage is reduced in a vacuum or inert atmosphere.

(2) The debris formed by the fretting of iron is largely Fe_2O_3.

(3) Greater damage occurs at low frequencies for a given number of cycles than at high frequencies.

(4) Metal loss increases with load and relative slip.

(5) Greater damage occurs below room temperature than above.

(6) The damage is greater in dry air than in moist air.

He proceeded on the assumption that there was a mechanical as well as a chemical factor concerned in the process, since micrographs show a definite disturbance or cold working of the surface. He suggests that an asperity, rubbing on the metal surface, produces a track of clean metal which immediately oxidises or upon which gas is rapidly adsorbed. The next asperity wipes off the oxide or initiates reaction of the metal with the adsorbed gas to form oxide. This constitutes the chemical factor. In addition, asperities dig below the surface to cause a certain amount of wear or shearing action, in which metal particles are dislodged. This is the mechanical factor in fretting. The metallic debris, produced by fretting, is thought not to oxidise spontaneously, but to become partially converted into iron oxide by a secondary fretting action in which the particles are rubbed against themselves or the adjacent surfaces. Ultimately Fe_2O_3 is the major corrosion product, and iron is found, if at all, in very small amount by X-ray analysis. In summing up, Uhlig proposes a quantitative expression or formula including a chemical factor and a mechanical factor for loss of weight in terms of load, number of cycles, frequency and slip. By interpreting the results of loss of weight experiments in the light of this formula, he found that the chemical factor might vary from 6 to 78 per cent of the total, depending on the conditions of test.

Remedial Measures

Damage due to fretting is liable to occur in all machinery subject to vibration. The debris may clog moving parts and the injury to the surface frequently leads to fatigue failure. The pits formed in fretted areas act as stress raisers, and fatigue cracks may start from them rather than from neighbouring keyways or other regions of high stress concentration. An example of this was given by L. E. Benson.§ In press-fitted axle assemblies, cold rolling of press fit regions is said to aid in the suppression of such failures, and in steam drop hammer piston-rods, interposing a soft copper shim between the rod and ram bore, at the press fit, or the use of a manganese bronze bush, delays the onset of fretting corrosion.‖

As a relative slip of one-millionth of an inch is sufficient to produce fretting, it is evidently not easy to suggest remedies. Nevertheless, H. H. Uhlig follows up his discussion of the mechanism of fretting corrosion by proposing some remedial measures. Excluding air from the metal interface by the use of special atmospheres, cements, or elastometer gaskets will reduce the chemical factor ; and with the exclusion of air the mechanical factor is also reduced as experiments with nitrogen showed. Metal transfer replaces metal loss with the formation of debris, the transfer being accompanied by cold working of the surface. Interposition at the interface of a substance that can bond itself to the metal surfaces with greater strength than it is bonded to itself would reduce damage. Unless the substance is metallic and a good thermal conductor it must have good high temperature characteristics because of the high local temperatures generated by friction in a poor conductor. The internal friction of the substance should be low to reduce the heat generated. Perhaps molybdenum disulphide, which is an effective high-temperature lubricant (up to about 800 deg. Cent.¶) and has been shown to be beneficial when fretting damage is expected, approaches these requirements.

It has been suggested that one surface of the interface be made flexible by the use of certain plastics or rubber, when fretting damage would be minimised presumably by eliminating relative slip. The interposition of a soft metal has been mentioned. In this case the load should approach the yield pressure of the soft metal to minimise the space between the asperities where oxidation occurs. Should any debris particles become embedded in the soft metal, they may continue to accelerate mechanical wear, but chemical action will be reduced by the exclusion of air from a large part of the surface.

These suggestions by H. H. Uhlig are interesting and worth following up, even though, in the light of practical experience, they would appear to be palliatives rather than cures for fretting corrosion.

Reduction of Residual Stress by Plastic Deformation

THE high residual stresses which may be left in a bar of steel when it is water quenched from the tempering temperature are shown in some experiments by H. Bühler,* who, with H. Buchholtz, was responsible for a considerable amount of work on internal stress before the war. Measurements of internal stress by the turning and boring-out methods of Heyn and Bauer and of Sachs were made on a carbon steel and a low nickel-chromium-molybdenum steel with the results shown in Table I.

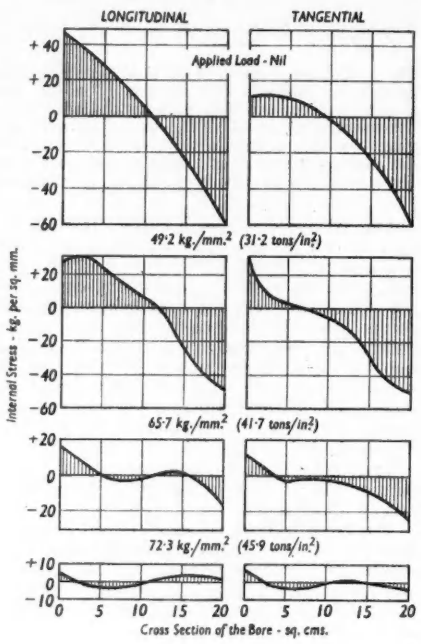


Fig. 1

A 0·42 per cent carbon steel, air cooled from 860 deg. Cent. and then reheated at 650 deg. Cent. for four hours and cooled in the furnace, gave similar tensile properties and was free from internal stress. It is clear that residual stresses, such as were found in steels A and B, can only be removed by the occurrence of plastic flow, induced either by the application of stress or by raising the temperature. It is known (and Buchholtz and Bühler† have contributed to this

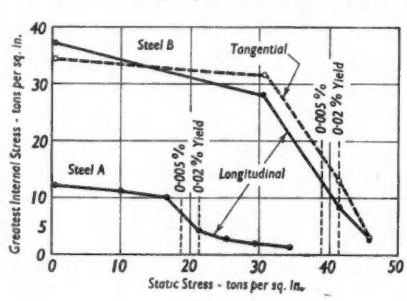


Fig. 2

* "The Mechanism of Fretting," *Lubrication Eng.*, June, 1953, Vol. 9, pages 134 and 158.
† *Journal of Applied Mechanics*, December, 1954, Vol. 21, page 395.
‡ *Journal of Applied Mechanics*, December, 1954, Vol. 21 page 401.
§ *Proc. I.Mech.E.*, March, 1940, Vol. 142, page 401.
‖ J. M. Lessells : *Strength and Resistance of Metals*, 1954, page 316 (London : Chapman and Hall, Ltd.).
¶ There is a very rapid increase in friction above 850 deg. Cent. F. P. Bowden : 41st Thomas Hawksley Lecture, Institution of Mechanical Engineers, 1954.
* *Archiv Eisenhüttenwesen*, January, 1955, page 51.
† *Ibid.*, 1932/33, Vol. 6, page 335.

TABLE I—*Composition, Properties and Greatest Values of Residual Stress**

Steel	Composition, per cent	Treatment	Load in tons/in², giving permanent set			Maximum load, tons/in²	Elongation, per cent, $L = 10d$	Reduction of area, per cent	Greatest residual stress, tons/sq in	
			0·005 per cent	0·01 per cent	0·2 per cent				Centre	Outside
A	C 0·31 Mn 0·73	850 deg. Cent./40 min/air 600 deg. Cent./1½ hr/water	19·7	20·6	21·9	36·3	21·6	50	+12·7	−12·7
B	C 0·27 Mn 0·76 Ni 1·12 Cr 0·74 Mo 0·28	850 deg. Cent./1½ hr/water 680 deg. Cent./4 hr/water (i) Outside ... ... (ii) Centre	 39·4 38·4	 41·0 39·9	 41·7 40·4	 48·5 47·4	 12·8 13·3	 72 70	Longitudinal +27·4 Tangential +8·3 (radial)	−37·8 −35·2

* Steel A was treated as 12mm diameter, steel B as 50mm diameter test pieces, both 2mm oversize before treatment.

information) that although micro-stresses in steel may be relieved by a moderate rise of temperature, e.g. 150 deg. to 300 deg. Cent., complete stress relief is only brought about by heating the steel to about 600 deg. Cent. A 60 : 40 brass cooled in the furnace from 225 deg. Cent. was shown in Bühler's experiments to be stress-free.

In non-ferrous alloys internal stress is frequently reduced by suitably applied cold work—for example, by reeling of tubes and rods. The object of the work now described by Bühler was to ascertain to what extent the residual stress in his steel specimens was removed by the application of static tension or compression stress. The effect on internal stress of stressing the alloy steel (B in Table I) is shown in Fig. 1. The course of the reduction in residual stress in both steels, brought about by the application of tensile loads, is shown in Fig. 2. Small static stresses had little effect, but there was a very considerable reduction in residual stress in specimens that had been stressed under a load corresponding to 0·005 per cent permanent set. After static stressing to about 0·2 per cent permanent set, the residual stress had fallen to about one-third of its original value, but almost complete removal of the residual stress required a still higher tensile load. The effect of static compression was similar, becoming very noticeable when a compression load corresponding to 0·005 per cent permanent compression had been applied. No residual stress was set up in originally stress-free specimens which had been loaded up to 0·2 per cent permanent set in tension.

Internal stress in a tensile test piece may result in early departure from proportionality, making measurement of the elastic modulus difficult and uncertain. This curvature may be reduced to negligible proportions by a very slight overstrain. Hence, Bühler's work is some justification of the common practice of applying and releasing a load producing the least detectable permanent set before taking measurements of Young's modulus.

The experiments indicate the magnitude of the stresses which may be induced by quenching in water from the tempering temperature. They may be abnormally high in steel B because the tempering temperature is rather near the critical range and because of the steep temperature gradient in this relatively small section, but they illustrate the danger that may be incurred by rapidly cooling a forging from the tempering temperature in order to obtain a high (and probably unnecessarily high) impact value. For many purposes, e.g. turbine discs and rotors, freedom from internal stress is of overriding importance, and in other connections also it is well to be reminded that dangerous residual stresses may arise not only from phase transformations in hardening, but in cooling from such temperatures as 600 deg. Cent. after tempering.

Short-Time Tensile Tests on 70 : 30 Nickel-Copper Alloys

SHORT-TIME tensile tests made on two 70 : 30 nickel-copper alloys at temperatures between 24 deg. and 927 deg. Cent. have been reported by W. D. Jenkins, T. G. Digges and C. R. Johnson.*

The materials used were a high-purity alloy containing nickel 70·1, copper 29·7 per cent, the chief impurity being silicon 0·12 per cent, and a commercial alloy (of approximately Monel metal composition) containing nickel 67·0, copper 29·8 per cent, with 1·56 per cent of iron and 0·89 per cent of manganese. At

* U.S. National Bureau of Standards, *Journal of Research*, January, 1955, Vol. 54, page 21.

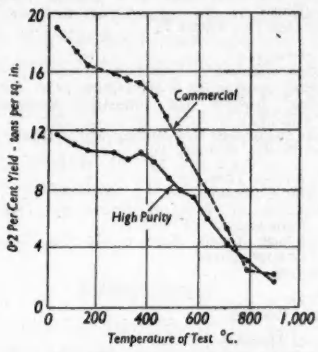


Fig. 1—70 : 30 nickel-copper. Effect of temperature on yield strength (0·2 per cent offset)

temperatures above 150 deg. Cent. discontinuous flow (shown by serrated stress-strain diagrams) occurred in both alloys, but was more noticeable in the high-purity alloy. At temperatures up to 482 deg. Cent. these discontinuities were attributed to strain ageing. Above that temperature they were held to be due mainly to recrystallisation and grain growth. Values of yield and tensile strength are shown in Figs. 1 and 2. Below 600 deg. Cent. the difference in composition had a considerable effect on properties, the strength being greater and the ductility less in the commercial alloy. Above 650 deg. Cent. the strength properties of the two alloys were similar, but the high-purity alloy retained a superiority in elongation and reduction of area. The difference in ductility of the two alloys was at a minimum at about 650 deg. Cent. (Fig. 3). In both alloys, the reduction of area remained

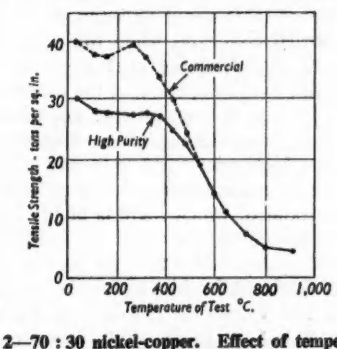


Fig. 2—70 : 30 nickel-copper. Effect of temperature on tensile strength

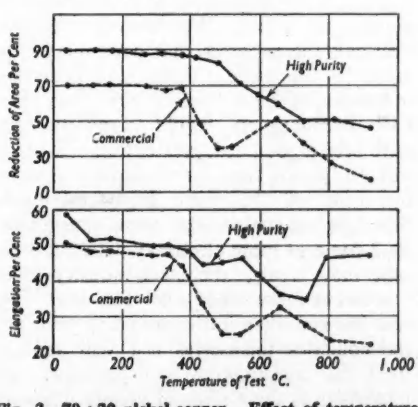


Fig. 3—70 : 30 nickel-copper. Effect of temperature on elongation and reduction of area

nearly constant up to 400 deg. Cent. and then diminished.

Titanium

A REPORT has now appeared of the symposium on titanium* arranged by the American Institute of Mining and Metallurgical Engineers in November, 1954. One of the points which came out in the discussion was that, at present, the use of titanium was mainly in the form of sheet, but that the tendency in the next year or two was likely to be more and more towards the production of forgings, and eventually perhaps of castings and powder metallurgical products. An outstanding difficulty in the production of castings is to find a suitable mould material. All materials so far tried contaminate the surface, so that castings have to be machined all over and the economic advantage of the casting process is thereby lost. In the discussion of the properties of the metal and its alloys, most interest was shown in the high-strength heat-treatable alloys and much less interest was displayed in possible applications in which corrosion resistance rather than strength/weight ratio was of importance. There was a demand for a higher modulus of elasticity, but it was agreed that the present value was not likely to be increased by more than about 2,000,000 lb per square inch (or about 15 per cent) by alloying. Improvement in homogeneity was called for and in this connection it was clear that the problems associated with the presence of elements which form interstitial solid solutions with titanium (viz., carbon, oxygen, nitrogen and hydrogen) were by no means settled. There was still some question as to the part played by oxygen, but it appeared that good material was low in oxygen. The U.S. Air Force specifications permit up to 0·20 per cent of oxygen in the $\alpha+\beta$ alloys of titanium, but nitrogen is limited to 0·07 per cent and hydrogen to 125 parts per million. Hydrogen appeared to be causing the greatest concern at the moment, and there was considerable discussion on how much could be tolerated. This question was discussed in a paper by H. D. Kessler, R. G. Sherman and J. F. Sullivan. All their results pointed to the conclusion that hydrogen should be kept below 0·015 per cent both in commercially pure titanium and in its alloys. Hydrogen may be the cause of a considerable loss of ductility. This was shown not only by low reduction of area in the tensile test, but by a test in which notched tensile specimens were loaded statically with a stress exceeding that required to fracture a plain bar. of cross section equal to that below the notch, and time to fracture noted. The tensile specimens were 0·250in diameter, with a 60 deg. "V"-notch, 0·178in root diameter and 0·005in root radius, stressed to 160,000 lb per square inch when the tensile strength of the unnotched bar was between 130,000 lb and 150,000 lb per square inch. The time to fracture should exceed twenty-four hours and always did so when the hydrogen was 0·015 per cent or less, but with 0·025 per cent of hydrogen the time fell to about four hours, with an occasional eight or twelve hours. Titanium alloys produced by vacuum melting always contained less than 0·015 per cent hydrogen provided that suitable precautions were taken in subsequent mill practice and annealing-furnace atmospheres. It could also be reduced below 0·01 per cent by a vacuum annealing treatment at 925 deg. Cent. Commercial titanium sheet which had been degassed in this way showed the anticipated improvement in properties ; for example, an increase in reduction of area from 8 to 48 per cent.

* *Journal of Metals*, February, 1955, page 234.

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COAL FOR INDUSTRY

Once again this country has managed to survive the "coal winter." The months which comprise that season, November to April, have not been altogether free from anxiety, but at no time during them has the coal supply situation been as critical as in some former years. At first glance, such a position appears satisfactory. Although coal stocks have dwindled during the winter, industrial establishments have not been slowed down through lack of fuel, train services have not had to be reduced, electricity generating stations have not had to impose power cuts, and domestic grates have not had, for long, to remain completely empty. Yet when the events of the past coal winter are examined in somewhat greater detail, it is quickly realised that the supply position could not have been maintained from this country's own resources. The situation has been saved by the regular arrival of the quantities of coal imported from overseas. Had there been available, throughout the winter, no more coal than the saleable output from our own mines and opencast sites, this country would certainly have suffered all the consequences of a fuel crisis.

The statistics of Britain's coal production and consumption are now so well known, especially to engineers, that they are apt to become monotonous if they are frequently recited! But it is impossible not to feel concern when it is realised that, last year, home coal production totalled 223,802,000 tons while inland consumption and export and bunker requirements amounted in all to 229,893,000 tons. Inland coal consumption last year, according to the published figures, was 6,000,000 tons higher than in 1953, whereas production was only about 300,000 tons greater. The production record in the first three months of the present year is no more encouraging. The statistics show that, so far, output is about 1,000,000 tons below the figure reached in the comparable period of last year, while consumption is about 600,000 tons higher. With little prospect of increased output, it became apparent last summer that steps must be taken to meet the rising trend of coal consumption, and the National Coal Board was authorised by the Government to extend imports. Coal imports last year, most of which arrived between August and December, therefore amounted to 3,000,000 tons. If the period of the coal winter is considered, the import figure is 4,500,000 tons purchased at a cost of £26,000,000. The Coal Board loses about £2 a ton on its sales of imported coal, and when full account is taken of our declining coal exports, it is likely that over the period of the recent coal winter the loss of overseas currency involved may well have amounted to £30,000,000. That is a high price to have to pay in order to maintain sufficient supplies of an essential raw material of which there is plenty in this land. But unless and until productivity in the coal mines rises above its present level, it is no doubt preferable to incur even so high a cost than to run the risk of a coal famine which would certainly slow down manufacturing industry at a time when its production is all important to the balance of payments position. We do not, of course, overlook the progress that continues to be made in the more efficient and economic utilisation of coal. Last year's increase in coal consumption would unquestionably have been a good deal greater than it actually was, had it not been for the savings effected by some of the more important users. British power stations, for example, generated 10·3 per cent more electricity with but 8 per cent more coal; the steel industry made 5 per cent more crude steel and used 7 per cent less coal than in the preceding year, and the collieries themselves last year reduced their coal consumption by 4 per cent. Yet important as these signs of greater efficiency are, it is equally important to keep in mind that, happily, British industrial activity is such that coal consumption, at present, continues to rise.

In a recent speech, the Minister of Fuel and Power said that the British coal industry had made a fresh start. He was referring to the reconstitution of the National Coal Board and to the Board's decision to give effect as speedily as possible to the principal recommendations of the advisory committee on organisation, which was presided over by Dr. Fleck. Most of those recommendations are concerned with matters of management. If greater flexibility in the management of the mines results in greater productivity below ground and on the surface the committee's task will not have been in vain, for it does not appear very likely that mining manpower will rise much above its present level in the immediate future. And it is the immediate future which is of importance to British industry. Capital expenditure in mines reconstruction is being stepped up and should soon begin to show results, whilst the projected industrial developments of nuclear power should ultimately ease the pressure on coal supplies. Neither of these objectives, however, will alleviate the short-term difficulty, a difficulty which during the past winter has proved expensive. It is a difficulty which can be eased, if not entirely removed, by a progressive rise in the mining productivity curve during the coal summer.

"SWEET THAMES RUN SOFTLY, TILL I END MY SONG"

The Thames has had to tolerate the imposition of many indignities during two score or so centuries of contact with the Londoners on her banks. Recently she has submitted to some very detailed, not to say personal, inquiries from two of the research stations of the D.S.I.R. The reports for 1954 of the Water Pollution Research Laboratory and the Hydraulics Research Station, which have been published within the last fortnight, both concern themselves to a large extent with investigations of various aspects of the behaviour of the Thames. The Water Pollution Research Laboratory has been carrying out a survey of the estuary to investigate the conditions of the river there, and its report contains information on the concentration of dissolved oxygen in the river and how it varies with changing conditions of the river, and gives information on factors affecting the river's "oxygen balance." A detailed report on the survey, which is described as "of great complexity," is expected later this year. The Hydraulics Research Station has studied the effects of storm surges in the estuary, and the properties of a surge-reducing barrage—i.e. a gated structure across the Thames at Woolwich or some such locality—which would be closed before a surge reached it, and hence prevent flooding in London. The behaviour of silt in the estuary has also been studied.

Last October, we commented on the proposal for a surge-reducing barrage, and pointed out that it reopened for discussion the pre-war Thames barrage idea, which envisaged the construction of a barrage with ship locks, which would turn the estuary above it into a fresh water lake with a substantially constant water level. These pro-

posals aroused strong opposition from the Port of London Authority and were finally dropped for reasons of national defence. Now that the Water Pollution Research Laboratory has established a relationship between the oxygen concentration in the river and the fresh water flow, it is possible to infer that the argument for a barrage as a method of preventing polluted water reaching the centre of London, is strengthened. The Laboratory's full report, which is intended as a guide to any policy of pollution control, may well elucidate this point. The work of the two Laboratories, taken together, will doubtless give an opportunity for consideration of future policy towards the river generally ; of how much flow can be used for power station cooling water, for instance, of what standard of purity sewage effluents must reach before discharge into the river, and of what need be done to give the best conditions for shipping using the P.L.A.'s installations, about the causes of silting, and of how all these aspects can be related to the wish of every Londoner for a clean and clear stream. The Thames estuary is, of course, heavily industrialised. It may well be that the purity of its waters compares favourably with that of other industrialised estuaries, such, for example, as those of the Tees and the Tyne. But upon the limited evidence before us, which reveals that at certain states of the tide oxygen is totally lacking from its waters as high up as London Bridge in the very centre of the City, a "favourable" comparison with other estuaries does not seem very impressive ! No doubt it is too much, within at least a generation or two, to expect to see limpid water from the Embankment and the South Bank promenade. It may never be possible since limpidity depends on absence of silt and the origin of the silt in Thames water does not seem yet to have been fairly established, though there may be a connection with oxygen content. But to suppose that little could be done to bring about improvement fails in justice to technological advances and slights the work of the Water Pollution Research Laboratory.

It is certainly convenient for industry and sometimes essential, as when no means of treating an industrial effluent has been discovered, to pollute the estuary. Yet a parallel with air pollution can be drawn. It is now much better appreciated than it once was that when industry pollutes the air it is being inefficient in fuel usage, not to mention in the calculation the costs imposed upon the community at large through the deterioration of buildings, the sicknesses of human beings and the effects upon agriculture. So, too, is it inefficient, we suggest, to pollute the waters. A century ago, London was subject to epidemics of water-borne diseases. They have been eliminated by providing through the work of the Thames Conservancy a tight control upon pollution of the non-tidal Thames ; by the bringing by the Metropolitan Water Board, mainly from the Thames itself, of a wholesome supply of water to London and by providing main drainage for every dwelling. Looking back we wonder at the tardiness of our forbears in providing these facilities, and, still more, at their arguments, seen in retrospect to be fallacious, that the expense was so great that it would rule out the universal adoption of the water carriage system of sewage disposal. To-day, we are faced with similar problems ; the air of London is heavily polluted, and its river is "anærobic" along a great length of its estuary. There was a time when a favourite theme of cartoonists in *Punch* and elsewhere was to "pillory" the state of the Thames, but such fun, although equally justifiable in its application to parts of the estuary, seems unfashionable nowadays. For our part we cannot help looking back nostalgically to Edmund Spenser's description of the fine prospect of the river in Elizabethan times, at the very place where our office is to-day. Perhaps, after all, it is not an impracticable ideal to restore to its former beauty, the "silver streaming Thames" of which he wrote.

Literature

The Testing of High-Speed Internal Combustion Engines. Fourth edition. By ARTHUR W. JUDGE. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 75s.

CHARLES F. KETTERING—then director of research at General Motors Corporation—tells of a man who, having witnessed a test on one of their engines, came to see him. "That is a very efficient engine," he said, "I would like to talk to your thermodynamics expert about it." "I am sorry," replied Kettering, "we don't have anyone here who even understands the word 'thermodynamics,' much less be an expert on it. But if you want to know how we developed this engine, I'll be glad to show you." Kettering's remark may occur to some of those who read the fourth edition of *The Testing of High-Speed Internal Combustion Engines*, since Mr. Judge has certainly described many of the tools by means of which designers of high-speed engines have been assisted in developing their engines to the level reached to-day. It is appropriate that conspicuous reference should have been made, by the author, to the paper read by William Froude in 1877, a paper wherein that perceptive genius quaintly observed how "to rely exclusively on the test furnished by the indicator is almost equivalent to testing the power of a horse solely by the quantity of food he consumes and digests, or the efficiency of a boiler solely by the quantity of coal per hour it will legitimately consume on its firebars." Strongly illustrative of the lack of knowledge eighty years ago is Froude's further remark that "It is certain that a very large but unmeasured amount of power is wasted in friction and otherwise, between the cylinders and the propeller ; and that the amount probably differs, both in respect of difference in type of engine, and in respect of goodness of construction and workmanship." It is to be noted that while Froude refers, in the remarks quoted, to dynamometers "for measuring the power delivered to the screws of large ships," Mr. Judge, writing nearly eighty years later, tells us that Froude's hydraulic dynamometer "has since been developed to a high degree of perfection, and is particularly suited to aircraft and automobile engine testing." This statement is certainly borne out by the number of references to this type of dynamometer which are found in the fourth edition of Mr. Judge's admirable book.

In Froude's time there were neither petrol engines nor oil engines, and it is most interesting to trace, in the present book, the development of those test engines which were used by Ricardo upwards of thirty years ago in connection with his researches into the influence of various fuels on the performance of internal combustion engines. The admirably illustrated section (pages 31–39) on "The Variable Compression Engine" is, indeed, one of the most instructive things in the book, followed as it is by details—with tables—of the standard of attainable efficiencies for four-stroke-cycle petrol engines evolved by Ricardo. In dealing with engine testing generally, Mr. Judge has distinguished between tests on production types and tests made in connection with research and development work. Considerable attention is given to compression-ignition engine testing, and in particular to the study of ignition lag or delay period, details being provided as to various methods for securing information not to be obtained from indicator diagrams. A very worthwhile addition to the book is a thirty-two-page section entitled "Gas Turbine Testing." Readers of this chapter will find it extremely informative and the very nature of the measurements necessary in connection with gas turbine tests reveals the fundamental differences between the reciprocating engine and the gas turbine. A hint of this is found in the statement that when making tests of the turbine unit "the dynamometer must be capable of measuring from *three to four times the rated output* of the complete gas turbine." In such a chapter, where details are given of test house layouts, test cells, thrust meters, control panels, speed recorders, instruments for pressure and temperature measurements, &c., it is most helpful to find tabular information giving the air pressures, temperatures and gas velocities in actual turbines.

Reading this finely illustrated book (there are as many as 398 illustrations distributed among 468 pages), we may deem the high-speed engine building industry as most fortunate in the research tools now at its disposal and on the great mass of research information which has been made available. Nevertheless, we shall be wise to remember a remark by Ricardo to the effect that it is upon the researcher rather than the research apparatus that true progress must depend. This does not, indeed, lessen the need for suitable tools and for the utilisation of all that science can provide in the way of instruments for measurement. Few indeed and crude, however, were the research tools at the disposal of the pioneers of the internal combustion engine. Imagination, a capacity for taking pains and that necessity which is ever the mother of invention, were the means which brought them at last to accomplishment. Many of us may need to be reminded that when, sixty-five years ago, Wilhelm von Oechelhaeuser and Hugo Junkers founded the laboratory for gas engines at Dessau, the first working room was a stable in the Dessau gasworks, and it was here that the first fundamental tests were made ("hier wurden die ersten grundlegenden Versuche durchgeführt"). While the testing of internal combustion engines—whether of high speed or any other description—is something which should receive the most competent attention assisted by the most advanced instrumentation, we would suggest to Mr. Judge that when yet another edition of his book is called for he might add a section devoted to tests carried out with a view to providing information as to how best to ensure long operating periods without overhaul ; how to maintain clean and complete combustion

at high engine speed and what are the conditions responsible for bearing failures and the cracking of bearing linings. There are many other matters on which the practical engine user looks—for information—to those whose business it is to deal constantly with engine tests, since the value of engine testing must be measured, in the last resort, by its influence on service performance.

An Introduction to Cost Accountancy. Volume II. By R. WARWICK DOBSON. London : Gee and Co. (Publishers), Ltd., 27, Basinghall Street, E.C.2. Price 25s.

THIS book further develops the subject initially discussed in Volume I and clearly sets out what are the elements of cost accounting and the methods employed. These fall under four main headings : cost information, cost bookkeeping, cost accounting systems, and cost audit. The subject is covered in nine chapters, XVI to XXIV, to carry on the sequence from the first volume. After a general examination of the ground to be covered, Chapter XVII is devoted to cost information with an explanation of its purpose and the form it should take ; Chapter XVIII leads us into the realm of bookkeeping, with double-entry and other forms explained, the necessity for control accounts is shown, and the basic documents needed are suggested ; in the next chapter an example of cost bookkeeping is given ; in Chapter XX we come to the application and design of the forms required for a costing system ; in Chapter XXI clerical procedures and methods are discussed, and the use of mechanical aids is explained. This chapter occupies over a third of the whole book and is well illustrated by photographs of the different machines available for duplicating and typewriting with an explanation of the advantages of electrical application, cash registering, accounting, time recording, addressing, tabulating, adding, calculating, and punching, including reproducing and verifying punches ; Chapter XXII gives a comprehensive insight into the cost accounting organisation, showing its place in the whole business and investigating the factors which determine the form and size of the organisation, attention being given to the small concern ; Chapter XXIII is occupied with procedure and instruction of staff, and the concluding chapter describes the cost audit as distinct from the better-known statutory audits of limited liability companies brought into being by the Companies Act of 1900. The author clearly shows the value of, and the necessity for, a cost audit, and the different forms it may take, this subject being one not usually touched on in books on cost accounting. The foregoing brief summary indicates the scope of a useful work.

The author rightly says that the primary job of costing and cost accounting is to furnish for the managers of a business " information of such a type as to enable them to control the costs of operating the business," and he might well have added that here ends the work of the cost accountant, for too often a manager is alienated by the attempt sometimes made to tell him how he ought to run his own side of the business. While we are informed that information may be presented in three different ways—narrative, pictorial and tabular—we are inclined to think that managers are less prepared to read reports than they are to study tables giving actual figures, from which they can suggest what graphs they consider desirable for the purpose of discussion with their staff. It is agreed that it is essential that the required cost information should be available "as soon as possible," for too often it arrives too late to be of practical value ; but on this point Mr. Dobson does not, indeed, owing to the different factors obtaining in each business, cannot, lay down any definite time standards. The value of personal contact between the cost accountant and the works management is stressed, and it is stated that in some cases the charge-hand should be brought into the picture ; we would even go further and recommend that when a modern costing system is being instituted, it is advisable to hold a meeting, or, if necessary, a series of meetings, to explain to every one, down to the most junior shop clerk, the purpose of the system, and the part to be played by each individual. Where this is done a harmonious atmosphere is established from the start.

Too often there is such an urge to get a system operating that necessary details are not considered as they should be, resulting perhaps in forms being adopted that are not really suitable for a particular factory ; in the preparation of forms it is essential to ensure from the outset that they will meet requirements. While the numerous photographs of different machines that may be invaluable as aids in cost accounting are very interesting, the engineer would like to know more as to the machines themselves and how they function, how, for example, the punched cards are mechanically sorted and selected ; but perhaps this may be claimed to be outside the scope of this volume. The author deals adequately with the organisation of a business, and the place in it held by the cost accountant, but while he definitely condemns dual responsibility as unsatisfactory he at the same time indicates that some of the staff may be responsible to others than their own chief. We should prefer him to affirm categorically that each member of the staff should have one chief, and one only, but at the same time he should be ever ready to co-operate with other functions. Bearing this in mind we should like Mr. Dobson to say whom he regards in the factory staff as the " opposite number " to the cost accountant ; this he hardly shows on his organisation charts. We should like to see each official given a definite designation.

The vexed question of centralisation versus decentralisation is carefully considered, and the advantages and disadvantages of each are examined, but a final decision must largely be influenced by the size of each particular business.

Having described various methods, the author gives as his verdict that the choice of method to be employed in carrying out the various operations must be considered when setting up a cost accounting system, and must largely be governed by the speed with which final results are required, the volume of documents to be handled, and the cost of the clerical work involved. Many managers do not appear to realise that the greater the detail required the higher will be the cost, and a perusal of this book should enable them to be more careful in determining what information is really essential.

Books Received

Gas Turbines for Aircraft. By I. H. Driggs and O. E. Lancaster. New York : The Ronald Press Company, 15, East Twenty-sixth Street, 10, N.Y., U.S.A. Price 10 dollars.

Principles of Engineering Thermodynamics. Second edition. By P. J. Kiefer, G. F. Kinney and M. C. Stuart. London : Chapman and Hall, Ltd., 37, Essex Street, Strand, W.C.2. Price 62s.

Fluid Mechanics with Engineering Applications. By R. L. Daugherty and A. C. Ingersoll. London : McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, E.C.4. Price 50s.

East Yelland Power Station

THE East Yelland power station of the Central Electricity Authority (South Western Division) was officially opened on Thursday, April 21st, by the Earl Fortescue, Lord Lieutenant of Devon. The power station, which is situated on East Yelland Marsh, about halfway between Barnstaple and Bideford, has a present installed capacity of 90MW, made up of three 30MW turbo-alternators and six 180k lb per hour boilers generating steam at 630 lb per square inch and 865 deg. Fah. Three more 30MW sets and five more 180k lb per hour boilers will be added in the second half of the station, giving an ultimate capacity of 180MW.

The boilers are fed by chain-grate stokers and grit arrestors are installed. In each half of the station the gases from the main flue will be discharged into an r.c. chimney, which is at present limited to a height of 117ft 6in (to meet Air Ministry requirements), but is designed so that it can be increased, later, to 214ft. Circulating water for the condensers is taken from the estuary of the River Taw, the intake being under the coaling jetty, which has facilities for unloading two colliers simultaneously by means of two electrically operated telpher transporters, each capable of handling 150 tons per hour. The output from the station will be transmitted from the adjoining 132kV grid outdoor substation to supply the North Devon area of the South Western Electricity Board.

Mr. Thirtle, South Western Divisional Controller, who introduced the Earl Fortescue at the opening ceremony, emphasised the importance of the station to North Devon, Somerset and Cornwall. He recalled that in the 1930s North Devon depended on diesel generation and a single 33kV overhead line between Bridgwater and Bideford. Since 1948 the supplies had been reinforced by a 132kV line from Taunton. With the new station reliable supplies were assumed ; an output of about 20MW would be required for the requirements of North Devon, and the remainder of the output would supply Taunton and North Cornwall. Before declaring the station open the Earl Fortescue said that electricity consumption in South West England was increasing at an annual rate of nearly 19 per cent. To meet the growing demand in that area, 271MW of generating plant had been installed since 1948. The East Yelland site was first considered in 1946 ; constructional work began in April, 1950 ; the first two 30MW sets were commissioned in 1953 and the first half of the 180MW station was completed in 1954.

Lloyd's Register Shipbuilding Returns

THE shipbuilding returns for the quarter ended March 31st, 1955, have been published this week by Lloyd's Register of Shipping. In Great Britain and Northern Ireland 335 steamships and motorships of 2,144,146 tons gross were under construction, of which 244 of 1,615,133 tons were still to be launched, the remainder being fitted and afloat. During the quarter 71 ships of 313,988 tons were commenced, 57 ships of 264,633 tons were launched, while the ships completed totalled 64 of 308,822 tons. A total of 91 ships of 756,072 tons, representing 35·3 per cent of the total tonnage being built in this country, were for registration abroad, and was 18,287 tons less than the previous quarter. Oil tankers formed 51·5 per cent of all the ships under construction and the total amounted to 86 ships of 1,104,368 tons. The volume of orders outstanding has fallen from a peak figure of 2,684,863 tons in September, 1952, to 1,359,118 tons, which was a decrease of 132,375 tons since last quarter, and the proportion of oil tankers has dropped from 62·6 to 48·0 per cent. Abroad the work in hand amounted to 941 ships of 3,819,041 tons gross, excluding China, Poland and Russia, and represented an increase of 105,546 tons since December. During the quarter the totals of ships commenced, launched, and completed were respectively 323 of 966,390 tons, 247 of 916,859 tons, and 226 of 867,935 tons. Tonnage for registration elsewhere than the country of build amounted to 1,431,770 tons, or 37·5 per cent. The total of oil tankers was 156 ships of 1,998,889 tons gross.

Physical Society Exhibition

No. II—(*Continued from page 568, April 22*)

THE thirty-ninth annual exhibition organised by the Physical Society was held at the Royal Horticultural Society's New Hall, London, this week and closed yesterday. Some of the exhibits of engineering interest are described below.

G.E.C. Research Laboratories

Demonstrations were given by the G.E.C. Research Laboratories, Wembley, Middlesex, to illustrate current developments in semi-conductors and their application. An item of particular interest was a full-wave bridge arrangement of four "EW54" germanium p-n junction power diodes, which was shown giving an output of 20A at 50V to a 1kW heating element. The "EW54" rectifier is stated to be the first germanium p-n junction for medium voltage and current circuits to become commercially available in this country.

The general construction of the "EW54" rectifier (which is 1¼in long and has a maximum diameter of ⅜in) can be seen from the diagram

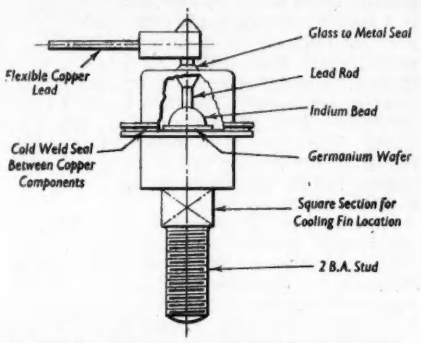


Fig. 5—Diagram showing construction of "EW54" germanium p-n junction power diode—G.E.C.

reproduced in Fig. 5. To protect the sensitive p-n junction from the effects of moisture the assembly is hermetically sealed in a container, in the presence of a neutral gas.

At an ambient temperature of 20 deg. Cent. the typical "EW54" rectifier passes a current of 8·0A at +0·5V and 6mA at −100V. Any increase in temperature results in an increase in both the reverse and forward currents at specified voltages. The rise in the reverse current means greater power dissipation, but the corresponding increase in forward current reduces the forward resistance and thus provides some slight compensation. In practice, the absolute maximum operating ambient temperature is 55 deg. Cent. and the maximum storage temperature 70 deg. Cent.

Cooling fins (Fig. 6), by increasing the heat dissipation of the device, raise the output power of the rectifiers. The following figures relating to a full-wave bridge arrangement operating into a resistive load with a smoothing choke (Fig. 7) illustrate this point :—

	Output at ambient temperature of 20 deg. Cent.		Output at ambient temperature of 55 deg. Cent.	
	V	A	V	A
Without cooling	50	6·8	50	2·4
With cooling ...	50	24·4	50	4·0

If the "EW54" exceeds its maximum dissipation rating the reverse current can rise further, which again increases the dissipation; this cumulative effect can cause a condition known as "runaway," which will result in permanent damage to the device.

If the efficiency of a full-wave rectifier circuit working into a resistive load be defined as the product of the mean d.c. output voltage and current divided by the product of the a.c. (r.m.s.) input voltage and current, then the maximum theoretical efficiency for any kind of rectifier is then 81 per cent when using a sinusoidal input wave form. The "EW54" rectifiers, used in a circuit of this kind, have a rectification efficiency of over 95 per cent of the limiting value.

Because of its low forward resistance, the "EW54" also exhibits good regulation. Thus, when a 50V r.m.s. input is applied to a full-wave bridge arrangement, the output voltage varies only between values of 45V at zero d.c. output

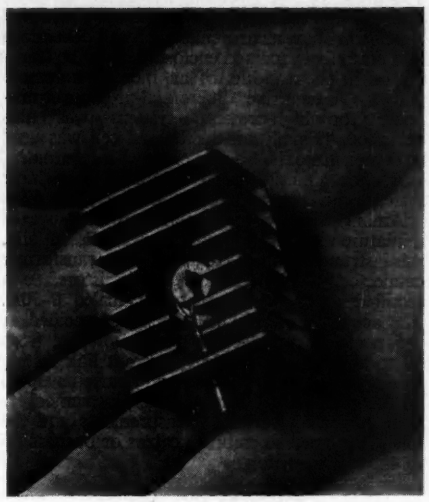


Fig. 6—"EW54" germanium p-n junction power diode with cooling fins. A full-wave bridge arrangement of four such units gives an output of 20A at 50V—G.E.C.

current and 44V at an output current of 20A. This small voltage drop corresponds to an internal forward resistance of about 0·05 ohm.

The "EW54" is suitable for operation at a.c. input frequencies of up to a few kilocycles per second, but, due to the "hole storage" effect, the efficiency is reduced at the higher frequencies; this means that the output ratings must also be reduced.

A carbon gauge developed for measuring the quality of a carburising atmosphere was also shown on this stand. The gauge consists essentially of an iron wire which is carburised in the atmosphere under test, and is then cooled rapidly

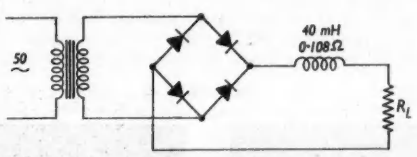


Fig. 7—Full-wave bridge arrangement of "EW54" units—G.E.C.

so that the wire transforms to martensite. In this condition its electrical resistance is a measure of its carbon content and hence of the carburising potential of the atmosphere. Values of the electrical resistance of the quenched wire can be directly related to carburising potential from a calibration curve. Operation of the gauge is straightforward and one measurement takes about fifteen minutes.

Another exhibit took the form of a model, demonstrating the principle of a 100-channel time-division multiplex (T.D.M.) electronic switch, showing how a telephonic connection could be established by supplying trains of ½ microsecond pulses of the same phase to two pulse-modulator/demodulator units. In this apparatus a single marker pulse determining the phase of pulse to be used is passed to magnetostriction delay line stores which thereafter supply the pulses to the modulator-demodulator units for the duration of the connection. It is suggested that a 100-channel T.D.M. switch of this kind may be used to serve 500 to 1000 subscribers and sixteen to twenty delay line stores will supply the necessary pulses.

Standard Telephones and Cables, Ltd.

Transistors and their applications were also shown by Standard Telephones and Cables, Ltd., Connaught House, London, W.C.2. As an example of the use of transistors in the voice frequency circuits of a telephone system, this company showed a prototype production version of transistor two-wire repeaters. The system consists of two-wire repeaters of orthodox design apart from the fact that transistors are used as the amplifying elements. Each repeater is suitable for terminal application to existing circuits and is complete with signalling by-pass circuits and line balancing networks. By employing adjustable feedback connections repeaters of this kind can be used for various duties.

Another application of transistors showed germanium diodes and triodes incorporated in a novel form of telephone. In this equipment, which is in production, dialling and listening facilities are provided as in the normal telephone service, but without any cord connection between the hand set and the sub-set or between the sub-set and any other equipment.

The Plessey Company, Ltd.

A magnetic store drum and input-output buffer units which are being developed for use with the Plessey payroll computer were shown by The Plessey Company, Ltd., Ilford, Essex. This magnetic store (Fig. 8) has a capacity of 100,000 elements in a surface medium of cobalt-rich cobalt-nickel alloy. A track spacing of sixteen to the inch and a digital spacing of approximately fifty to the inch is used. The mumetal heads have an impedance of 25 ohms

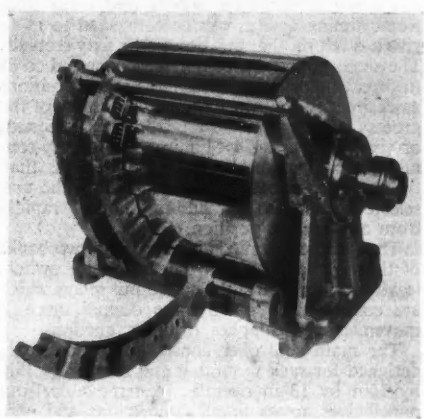


Fig. 8—Magnetic storage drum developed for use with the Plessey payroll computer—Plessey

and a playback amplitude of about 10 millivolts. The peripheral velocity of the drum is approximately 900in per second.

Each buffer storage unit (input and output) stores sixteen decimal digits. Five such units may be used either to store, or to punch all eighty columns of a standard Hollerith card using standard equipment. By the use of input/output buffer storage, computing can be done as cards are being read and punched. The individual storage elements in the buffers are dekatron tubes, which are used in the arithmetic unit of the computer proper. The power consumption is approximately 250 milliwatts per decimal digit for the input buffer and approximately 1W per digit for the output buffer.

A windscreen heat controller (developed under Ministry of Supply contract for use in conjunction with conducting windscreens) was shown. It provides, automatically, preheating of the screens from a low-temperature start, control of the normal working temperature of 50 deg. Cent. within a few degrees, and prevention of windscreen overheating in the event of a fault developing elsewhere in the circuits. Another exhibit was a windscreen de-icing controller which gives continuous power control by means of magnetic amplifiers and a power-handling saturable reactor. It makes use of two 100 ohm wire-

sensing elements, one for temperature control and the other for overheat protection. Pre-heating of the screen is provided automatically if the temperature of the screen is below a given temperature.

Edison Swan Electric Company, Ltd.

An electronic controller which is designed to serve as the controlling element in an automatic production plant was shown by the Edison Swan Electric Company, Ltd. It is suitable for any kind of mechanical process the controls of which can be electrically or pneumatically operated ; it can control six functions and it has been successfully used for automatic glass work.

Essentially, it is a universal timer controlling up to six separate and individual functions in such a way that they are automatically initiated and stopped in the correct sequence and at the correct time. Auxiliary units are available, which introduce further sequences of switching, and they are of particular use where gas and oxygen have to be controlled in combustion.

The timing sequence is initiated from a separate control box, which can be placed conveniently for the operator ; it contains a push button for initiation and an emergency stop switch which turns off all supplies and returns the timer to the starting position.

The total time of the desired operation is divided into twenty-four or less units of time, some of which are " basic " short periods, dictated by the shortest times at which one operation is required to follow another, and others can be increased up to one minute by the connection of calibrated time-delay devices. This arrangement is achieved by having an eight-bank, twenty-four-position uniselector switch, normally impulsed by the basic short period timer, which can be set from approximately one-quarter second to five seconds. At any position, however, one of four other electronic timing devices can be connected so as to give a dwell on that position up to sixty seconds. The same timing device may be connected so as to repeat its delaying effect in as many positions as desired, so that the extreme limitations of the process to be controlled are from 24×¼ seconds or six seconds, to 24×1 minute or twenty-four minutes. If the total process requires less than twenty-four periods for its completion, the uniselector switch can be made to " home " rapidly from any desired position.

The facilities detailed above take up two banks of the eight available in the uniselector switch, leaving six to control the six output relays which are connected to operate the desired machine movements, gas supplies, or other functions.

The main controller consists of an assembly designed for rack mounting and measuring 19in by 16in by 13½in overall. A removable front panel gives access to all connections and controls, and allows for setting the desired operation programme. The back cover is removable for maintenance. The starter is a separate unit, 5½in by 3½in by 2½in. One form of auxiliary unit, " A " is 6in by 6in by 6in ; it provides a delay between two switched outputs, suitable for (say) oxygen and gas. The other auxiliary unit " B " is 18in. by 6in. by 6in ; it will increase an oxygen supply, for example, in several set stages, after initiation by the main control.

The controller works from 240V, 50 c/s mains, and it will switch either mains voltages or 50V d.c. to external control equipment.

Salford Electrical Instruments Ltd.

Recent developments in the S.E.I. transducer system were demonstrated by Salford Electrical Instruments, Ltd., Silk Street, Salford 3, Lancs. The use of the remote-indicating absolute pressure transmitter, for example, was illustrated by showing how measurements of wall deflections in a partially evacuated enclosure could be transmitted in thousandths of an inch to a remote point. A sensitive differential-pressure transducer for high-pressure systems was also exhibited. Finally an S.E.I. load cell was used to demonstrate the tractive effort of a solenoid.

A short description of the S.E.I. transducer system is given elsewhere in this issue (page 594).

Among the new instruments on show was a miniature a.c. link-testing ammeter. Essentially, this instrument consists of a split-core transformer connected, through shunts and resistors, to a rectified moving-coil instrument scaled 0–50A. The accuracy of this instrument is specified as ±5 per cent of full-scale reading on a.c. from 40 to 80 c/s. A new heavy-current link testing ammeter designed for measuring currents up to 5000A was also shown. This instrument is suitable for a.c. or d.c. measurements and the link is designed to embrace cables or busbars up to 4in by 2in section.

Saunders Roe, Ltd.

A computing amplifier (Fig. 9) designed for use in slow-speed d.c. analogue computers or for high-speed repetitive computing, was shown by the electronics division of Saunders Roe, Ltd., East Cowes, Isle of Wight. It consists of a high-gain drift-corrected amplifier with a drift-compensated unity-gain amplifier as a sign reverser. The main amplifier is designed to perform the operations of summation, integration and differentiation, and to provide any desired transfer function when used in conjunction with suitable computing impedances.

This company also showed a four-quadrant electronic multiplier for use in d.c. analogue computers. It is capable of yielding the product of two voltages having a maximum amplitude of ±50V with an accuracy to ±1 per cent. The frequency range at either input is 0 to 200 c/s, making it suitable for real time computations or repetitive working.

Another exhibit consisted of a displacement meter and its associated pick-off heads which have been designed to offer a high degree of stability and accuracy.* Displacement is indicated as deflection on the panel-mounted meter (Fig. 10). Facilities are provided for connection of the output stages to suitable recorders, and, for this purpose, 75mV from 600 ohms source corresponds to meter full-scale deflection. The instrument is supplied for single-channel working, but adaptor accessories are available to add channels in multiples of six.

Ferranti, Ltd.

The application of electronics to the problem of measuring the relative displacement of two objects (on a machine tool, for example) was demonstrated by Ferranti, Ltd., Hollinwood, Lancs.

Prismatic gratings consisting of glass strips carrying a line structure form the basis of this method of measurement. A beam of parallel light rays is passed through two such gratings, superimposed so that the movement of one grating relatively to the other produces a modulated light pattern which varies through one complete cycle of light and darkness for a relative movement equivalent to the width of one line.

To apply this principle to the measurement of the displacement of a machine tool table, for example, a long grating is fixed to the table and two parallel light beams are passed through this grating and through a small stationary grating. Both beams are collected and passed to two separate photo-electric cells, each of which gives an electrical pulse each time the light is unobscured. These pulses are counted as the table moves and the count gives an exact measurement of the travel. The use of two beams of light allows for discrimination of the direction of travel. The accuracy of measurement is determined by the spacing of the lines and, with a grating having 5000 lines per inch, control to 0·0001in can be obtained.

Another exhibit showed a new version of electronic digital computer—the Ferranti packaged computer No. 1, which is known as " Pegasus " and is designed to serve as a general-purpose computer suitable for a wide variety of calculations in industry, commerce and scientific research.* In this computer the emphasis is on the provision of facilities which simplify the preparatory work involved in a calculation. " Pegasus " is built from standardised plug-in unit assemblies, to simplify maintenance and replacement. Computation takes place in an immediate access store of forty-three single-word registers, consisting of nickel delay lines. This immediate access store is backed up by a magnetic drum store with a capacity of 4096 words.

B.T.H. Research Laboratory

Recent research work on various kinds of glass was the subject of a group of exhibits shown by the Research Laboratory, The British Thomson-Houston Company, Ltd. Rugby. One group of glasses which have been developed

* The Engineer, March 4, 1955, pages 303-4.

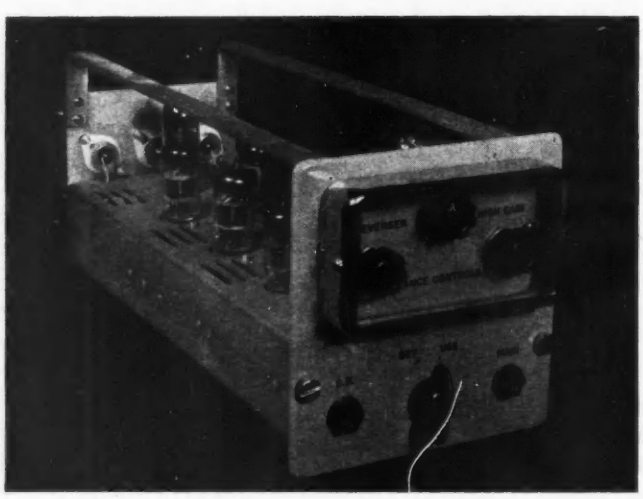


Fig. 9—Computing amplifier for use in slow-speed d.c. analogue computers or high-speed repetitive computers—Saunders Roe

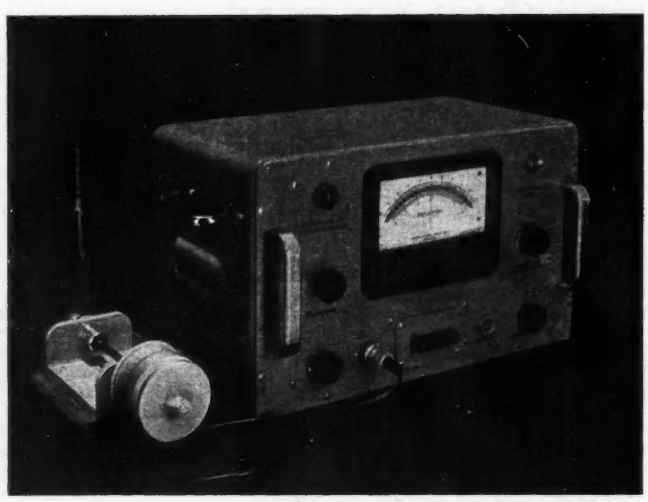


Fig. 10—Displacement meter and pick-off head—Saunders Roe

contain very little of the well-known glass-forming oxides, such as boric oxide. Other samples that were shown included glasses based on calcium aluminate, which have useful infra-red transmission characteristics, glasses based on tellurium dioxide which have high values of refractive index and dielectric constant, and glasses based on vanadium pentoxide, which are semi-conductors at room temperatures. A demonstration was given of the semi-conductivity of vanadate glass.

Samples were also shown to illustrate progress in the development of semi-conductors and their applications.

Materials and techniques for high-voltage insulation with moulded synthetic rubbers were typified in an exhibit consisting of 11kV current transformer coils insulated with butyl rubber by injection moulding. The disposition of the copper coils within the mouldings and the uniformity of the insulation were shown on X-ray photographs.

Part of the B.T.H. stand was devoted to lamps and lighting and a new 4W long-wave ultra-violet (3650Å) source was shown. This lamp is similar to a normal fluorescent lamp except that it contains a special phosphor to convert the 2537Å emission from the arc into ultra-violet, long-wave radiation, instead of visible light. The tube is of Woods glass, which filters out the small amount of visible blue light and the short wavelength ultra-violet radiation. The efficiency of the ultra-violet source is about eighty times that of the tungsten filament and there is no run-up time delay as there is with the high-pressure mercury vapour lamp. It is applicable to many duties hitherto performed by tungsten filament, black glass ultra-violet lamps and 125W high-pressure mercury vapour ultra-violet lamps. Two particular applications demonstrated were those of illuminating instruments in aircraft cockpits, and hand torches for detecting leaks in condenser tubes.

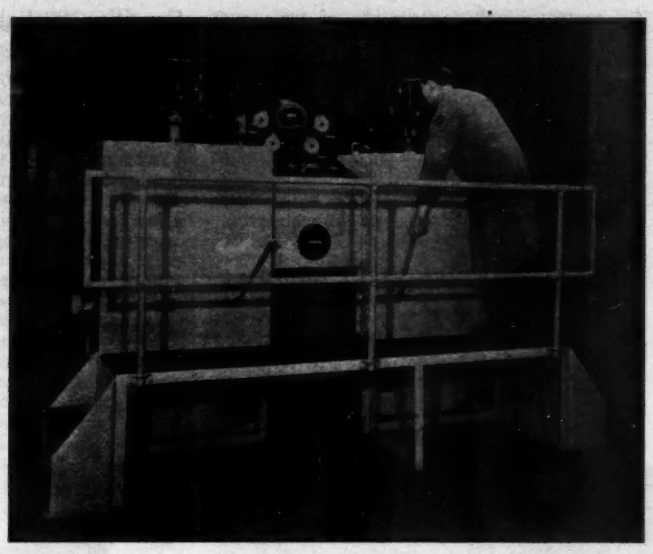
(To be continued)

Vacuum and Pressure Impregnating Plant

IMPREGNATION with varnishes or chemicals is used in many industries, chiefly in electrical manufacture, but also, for instance, in the making of pencils and in the repair of porous castings. A plant in which alternate vacuum and pressure treatment can be carried out is shown in the illustration. In this design, made by Blickvac Engineering, Ltd., Bede Trading Estate, Jarrow, two autoclaves, each with a heated storage vessel, are provided. Compared with the firm's single unit, the twin arrangement allows a better utilisation of the associated vacuum pump and compressor (or air line), since these items can be kept in almost constant operation.

Both the autoclaves and the storage containers are electrically heated by separate thermostatically controlled oil baths. In plants which are intended exclusively for cold varnish, the storage vessels may be unheated. The temperatures may be adjusted within the range 40 deg. to 160 deg. Cent. in the standard machines, or higher if required.

The autoclaves are constructed for a working pressure of 80 lb per square inch and have lids which can be swung in and out of position on an arm. Two windows of toughened glass are fitted, one for observation and the other for mounting an inspection lamp. In order to protect it from damage due to vibration, the pipework is mounted in shock absorbers, and connections are made by means of O-rings, which have the required degree of flexibility. The pipes have been arranged so as to make it easy to dismantle them for cleaning should they become obstructed. For the removal of moisture a horizontal tray with desiccant is fitted as a standard, but other kinds of trap, e.g. for solvent absorption, are available.



Impregnating units with two autoclaves served by common vacuum pump and air line (or compressor). While one autoclave is put under pressure, the other is evacuated

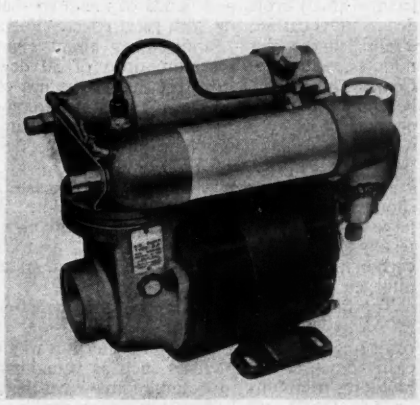
Rubber diaphragm valves control the circuits, and for pressure measurements two Bourdon gauges (vacuum and positive pressures) and one 0–10mm Hg McLeod gauge are fitted.

Positive pressure is normally supplied from the factory compressed air line, but where this is not available a compressor is incorporated in the plant. Motors can be supplied to operate on either single-phase or three-phase a.c., as required. All controls are centralised so that it is easy for the machine to be operated by a semi-skilled or a disabled person.

Small Capacity Air Compressor

Two new diaphragm design air compressors are being made by the Hymatic Engineering Company, Ltd., Redditch, Worcs, for use where small quantities of compressed air at low pressures and free from oil vapour are required. Each of these compressors is designed to provide a free air delivery of 2½ cubic feet per minute at 35 lb per square inch. One model is arranged for belt pulley drive and the other, illustrated below, is supplied complete with a driving motor.

In these compressors a cast aluminium connecting-rod has its top shaped as a circular disc on which the diaphragm seats. The outer edge of the diaphragm is gripped and sealed between the main body casting and the compressor head. At the top of its compression stroke the connecting-rod disc comforms to the contour of the diaphragm. A plate above the diaphragm holds it in position on the disc and is fitted with a reed design inlet valve. A stainless steel delivery valve of the same design is fitted in the aluminium alloy head of the compression chamber.



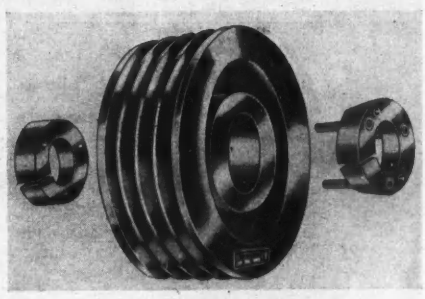
Motor-driven air compressor with a free air delivery capacity of 2 cubic f.p.m. at 35 lb per square inch

At its bottom end the connecting-rod is split to house a grease-packed sealed ball race which forms a big end bearing. The bearings of the hollow overhung crankshaft are also grease packed so that no servicing should be necessary between major overhauls of the compressor. The compressor is flange mounted on the electric motor and, as can be seen in the illustration, two air storage bottles complete the unit.

Keyless Driving Pulleys

THE vee-rope pulleys made by the Zerney Engineering Company, Ltd., of Rickmansworth, Herts, are now available with a new form of shaft attachment which eliminates need for keys, screws or other driving connections between the pulley and the shaft. This hub fitting, known as the "Dualok," is quick and easy to fit and, as can be seen from the accompanying illustration, simply consists of two coned bushes connected by screws.

The bushes, which are split, are bored about 0·002in oversize to the appropriate shaft and their circumferential faces are tapered. A corresponding taper is machined in each end of the pulley bore. When fitting the pulley on a shaft the bushes are first placed in the bore and loosely held by the three screws. The assembly can then be easily slid to the required position on the shaft and, on the screws being tightened, the bushes are drawn into the tapered bores in the pulley. The wedging action imparted by the coned faces rigidly clamps the bushes in the pulley and on the shaft. There are no projecting parts when the pulley is fast on the shaft as socket head screws are used and the faces of the bushes are flush with the pulley boss.



Keyless pulley with the split coned bushes which are used to lock it on a shaft

When it is required to remove a pulley with this form of hub attachment the three screws are removed and two are screwed through threaded holes in one of the bushes. On forcing home these two screws against the inner face of the opposite bush the jacking action brings the bushes out of engagement with the hub and the shaft.

We are informed that the firm is now making single and multi-groove pulleys for various section vee ropes up to 42in diameter with the "Dualok" shaft fitting. The bushes can also be supplied for use with other types of pulleys and are made in a number of standard sizes for use on shafts from ½in to 4in diameter.

BRITISH ASSOCIATION.—The 117th annual meeting of the British Association for the Advancement of Science is to be held at Bristol from August 31st to September 7th next, under the presidency of Sir Robert Robinson, O.M., F.R.S. Sir Robert will deliver his presidential address on "Science and the Scientist" in the Colston Hall, Bristol, on Wednesday evening, August 31st. Evening discourses to be delivered during the meeting include "Experiments at Great Altitudes with Free Balloons," by Professor C. F. Powell; "Stonehenge in the Light of Recent Research," by Mr. B. J. C. Atkinson, and "Scientific and Dramatic Modes of Thought," by Professor H. D. F. Kitto. Dr. S. F. Dorey, F.R.S., is the president this year of Section G, Engineering. His address, to be delivered on Thursday morning, September 1st, will be entitled "The Influence of the Engineer on Sea Transport and Trade."

Industrial Vacuum Casting of Steel

A SERIOUS cause of trouble in steel castings, especially with the very heavy castings nowadays required for power station turbines and generators, is the presence of hydrogen (and to a lesser extent that of other gases). Hydrogen is absorbed by the molten metal and on solidification is liberated into tiny pockets; the extreme pressures which are set up in this way cause a reduction in the tensile and impact strengths of the casting as a whole.

Almost all the raw materials and fuels used in the manufacture of steel contain greater or lesser amounts of hydrogen, either as an element or in combination as water vapour or hydrocarbons. It is, therefore, not possible in practice to prevent its introduction into the metal. On a laboratory scale vacuum furnaces have been used, but the only remedy so far available industrially has been to employ greatly prolonged cooling times and special heat treatments to give the gas time to diffuse out. With heavy sections, this procedure is extremely time-consuming and costly.

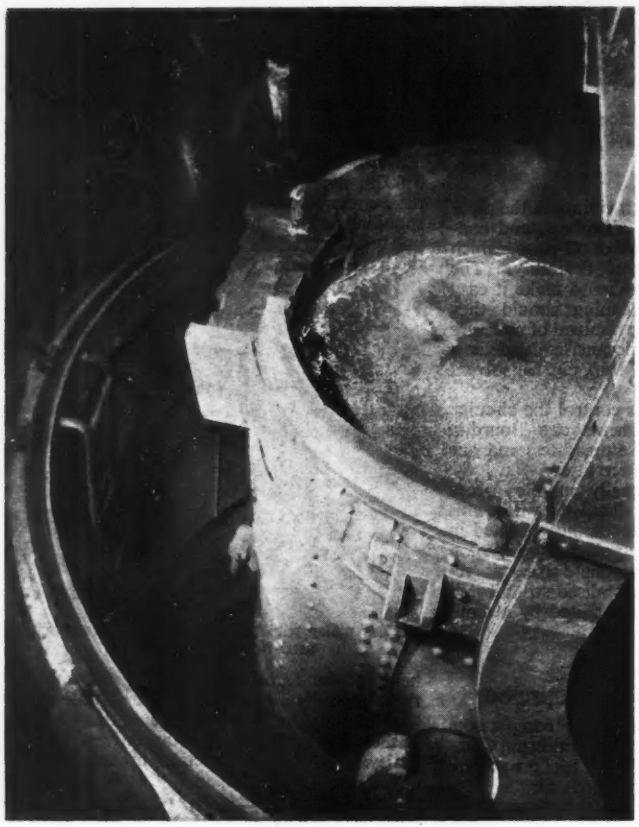
Although an industrial vacuum furnace was considered impracticable, the Gusstahlwerk Bochumer Verein A.G., Bochum, in 1950 began work on the vacuum extraction of gas from molten steel prepared in the conventional way.

The first procedure which was tried was to place a ladle holding up to 20 lb of metal into a container and to pump the air out. The success of these trials led to the construction, two years later, of a larger installation. One of the chief initial difficulties had been the question of pumps. Pressures of 30mm Hg or less were required, and although water jet pumps were adequate for such pressures, it was found that hydrogen tended to be reintroduced by the back-diffusion of water vapour. The new plant, which was to operate in conjunction with a 40-ton electric melting furnace, was therefore equipped with mechanical pumps, three Leybold pumps each of 600 cubic metres per hour capacity being used. The present installation consists of two containers of 2·4m internal diameter and 4·2m height, each capable of dealing with two 35-ton ingots per day. In addition there is a container of 4·4m internal diameter and 9m height (shown in the illustration) for ingots of up to 150 tons. This equipment is served by a 5000 cubic metres per hour pumping section consisting of eight Leybold high-vacuum pumps and one backing pump. A pressure of 30mm Hg can be reached in about five minutes, while the ultimate pressure which may be attained in the system is 0·2mm Hg.

Improvements in efficiency are possible by exposing the molten metal to the vacuum in the form of a thin jet. This is done by placing an empty casting ladle, or the ingot mould itself, inside the container, the lid of which is fitted with a nozzle. A vacuum is established, the nozzle being kept closed by means of a thin aluminium disc which is melted as the steel is poured. The whole process can be observed through windows, and high-speed films have shown that the emptying gases break up the jet into small drops and bands of metal so that degassing is carried out with great effect. For a 40-ton charge the pouring takes about eight minutes, with a temperature drop of 30 deg. Cent. This cooling down of the charge has to be kept to a minimum since it cannot be compensated for by a higher initial temperature without the metal absorbing additional gas at the higher temperature.

Analysis of the pump exhaust during casting shows that oxygen was practically absent. A large number of tests gave the approximate mean results, in per cent by volume: hydrogen 20, carbon monoxide 45, carbon dioxide 5, remainder nitrogen.

The firm states that apart from the extraction of hydrogen, the simultaneous exclusion of oxygen is of particular importance in cases where easily oxydised components such as vanadium, niobium, titanium, or aluminium, have been added. During the last two years the output of ingots and of special castings in various alloy steels totalled over 10,000 tons.



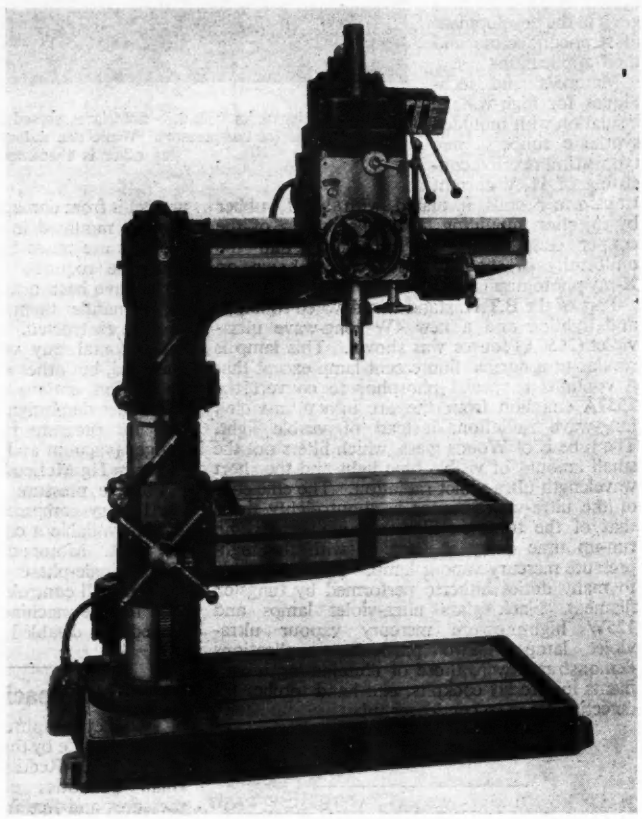
A ladle with de-gassed steel being raised from a vacuum chamber. This chamber is 4·4m diameter by 9m high and takes up to 150 tons of steel

Sensitive Radial Drilling Machine

A 42in sensitive radial drilling machine recently introduced by Fredk. Town and Sons, Ltd., Mile Cross Works, Halifax, has a capacity for drilling up to 1¼in in mild steel or 1½in in cast iron, or tapping holes up to ¾in Whitworth. As can be seen from the accompanying illustration, the machine is mounted on a substantial tee-slotted base-plate which has a working surface 3ft 6in long by 2ft 4in wide. The saddle arm pivoted on ball bearings at the top of the pillar has large ways on which the box-form saddle is traversed over a length of 2ft 9in through a steel rack and pinion, and it can be firmly locked in any required position.

The spindle of the saddle is bored to take No. 3 Morse taper and is driven through change gears by a 2 h.p. reversing motor to give nine speeds from 88 r.p.m. to 1450 r.p.m. or, alternatively, from 60 r.p.m. to 1000 r.p.m. The three rates of spindle power feed from 80 to 200 revolutions per inch, or 0·013in to 0·005in per revolution, are selected by a lever on the front of the saddle. Direct reading plates show the correct speeds and feeds for different drill diameters when machining cast iron or steel. The spindle has a maximum traverse of 9½in and an automatic depth drilling stop can be set in any part of the traverse. Lubricant is supplied to all working parts of the saddle by an integral oil pump.

The table has a long bearing in the pillar and is adjusted vertically by means of a star handle through worm gearing, rack and pinion, over a height of 17in. With a slotted working surface 3ft long by 2ft wide, this table also has a vee groove in its machined front face to facilitate work mounting. When required the table can be swung clear so that large workpieces can be mounted directly on the base-plate. The maximum distance from the spindle to the base-plate is 3ft 7½in and from the spindle to the table surface 2ft 4½in.



42in radial drilling and tapping machine

SEARCH FOR NATURAL GAS.—We are informed that the D'Arcy Exploration Company, which is prospecting for natural gas on behalf of the Gas Council, will start survey work in the Cheshire Basin this summer.

I.E.E. Faraday Medal and Certificate of Honorary Membership

AT a meeting of the Institution of Electrical Engineers on April 21, 1955, the president of the Institution, Mr. J. Eccles, presented the I.E.E. Certificate of Honorary Membership to Mr. James Robert Beard, " for his distinguished services to the profession, more especially in the field of the transmission and distribution of electricity and for his valuable services to the Institution."

It will be recalled that Mr. Beard was closely associated with the design and construction of the national grid system and with many other power supply and traction schemes in this country and abroad. He has served on the panel of technical advisers to the North of Scotland Hydro-Electric Board since its formation in 1943. He spent his post-graduate years with the Newcastle upon Tyne Electric Supply Company and the Cleveland and Durham Electric Power Company, later joining Messrs. Merz and McLellan as assistant to Mr. P. V. Hunter, whom he succeeded as chief electrical engineer. Mr. Beard is now senior partner of the firm. He has performed outstanding services for the Institution over a long period of years : he was elected chairman of the North-Eastern Centre in 1920, and in 1927 and again in 1934 he was elected a member of council. He first took office as vice-president in 1937 and served as president of the Institution in 1940.

The president later presented the Institution's Faraday Medal to Sir John Cockcroft, Director of the Atomic Energy Research Establishment, Harwell, " for the conspicuous services he has rendered to the advancement of electrical science, for his distinguished work in the field of nuclear physics and the development of power from nuclear sources."

Sir John Cockcroft is a member of the Institution, his first election as an associate member having taken place in 1927. He served on the council of the Institution from 1942 to 1945. Educated at Manchester University, he received his practical training as a college apprentice with the Metropolitan-Vickers Electrical Company, Ltd. After serving on the company's research staff under Sir Arthur Fleming he was appointed in 1927 as consulting physicist to the company.

In 1930 he was appointed university demonstrator and lecturer in physics at the Cavendish Laboratory, Cambridge. There, under Lord Rutherford, he developed apparatus for producing high-velocity positive ions, with which, in 1932, he and E. T. S. Walton were the first to disintegrate the nucleus of an element by the use of artificially accelerated protons. The immediate importance of these experiments lay in their confirmation of Gamow's theory of potential barrier penetration, according to which nuclear disintegrations might be produced by light particles of relatively low energy. The way to the study of a great variety of nuclear reactions was thus opened, and with the successful application elsewhere of the cyclotron and electrostatic generator in similar work a rapid expansion of experimental nuclear physics took place.

Throughout his period at the Cavendish he was closely associated with all the notable achievements of the Laboratory, and in 1939 he succeeded Sir Edward Appleton as Jacksonian Professor of Natural Philosophy. Throughout the war years he was urgently in demand as adviser to many Government departments. He held the post of Director of the Air Defence Research and Development Establishment (later R.R.D.E.) of the Ministry of Supply at Christchurch and Malvern, and subsequently that of Director of the Montreal Laboratory of the National Research Council of Canada. He received his present appointment in 1946, and has been responsible for a period of most intensive development in the field of nuclear energy and its applications.

After the presentation of these awards the forty-sixth Kelvin Lecture of the Institution of Electrical Engineers was delivered by Dr. W. Shockley on " Transistor Physics."

Pipe Bifurcations for Hydro-Electric Schemes

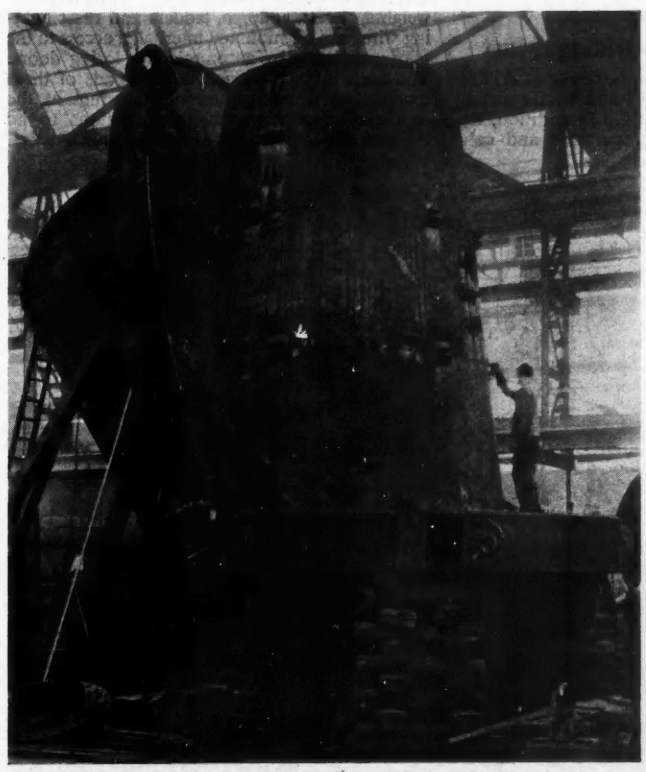
WE give in this note some data on two recent German examples of the construction of pipe bifurcations in the penstocks of hydro-electric schemes. Our first illustration shows the assembly, at the maker's works, of the bifurcation pipe for the Big Eildon power station in Australia. The scheme was briefly described in our issue of March 11th last, and on page 333 of that issue the bifurcation can be seen in position. Some data concerning the bifurcation are given in the table. It was manufactured by Fried. Krupp A.G., of Rheinhausen.

Model of pipe bifurcation for the Lech scheme at Rosshaupton

We also illustrate a model of a pipe bifurcation for a power station near Rosshaupton. It has a length of 11,000mm, and inlet and outlet diameters of 7500mm and 4500mm respectively ; its weight is 165 tonnes, and it is to take a flow of 150 cumecs to two Kaplan turbines, each of 24MW capacity. The detailing of the welded construction of the bifurcation is clearly shown in the illustration. It utilises an alloy steel containing aluminium and silicon. Some provision for movement is allowed at the supports, and the site welds were tested with X-rays and ultrasonically. The bifurcation was made by the firm of Stahlbau Lavis, of Offenbach a. M.

Bifurcation Pipe for Big Eildon Power Station

Inlet diameter, mm	7,010
Outlet diameter, mm	4,420
Length, mm	8,400
Length of " horseshoe " brace, mm	8,350
Max. diameter of " ring " brace, mm	10,730
Pipe thickness at inlet, mm	32
Weight, tonnes	130
Static head, atmospheres (gauge)	7·6
Flow, cumecs	170
Power supplied, MW	60



Assembly at maker's works of pipe bifurcation for Big Eildon power station

Demonstration of Military Engineering Equipment

LAST week representatives from a number of firms supplying equipment to the Directorate of Royal Engineers Equipment/Military Engineering Experimental Equipment Establishment were invited by the Ministry of Supply to visit the Military Engineering Establishment at Christchurch to see demonstrations of selected military engineering equipments now under development. The demonstrations were mainly concerned with the equipment such as is used in civil engineering work as adapted and developed for military requirements. In the course of an introductory talk by the chief superintendent and other addresses given during the course of the day, it was pointed out how closely modern equipment developments were followed, and how, in specifying for military requirements, the establishment was instrumental in promoting development work, both useful to manufacturers and of value to industry.

The first demonstration was concerned with bridging and ferrying equipment for troops and equipment. In it there was shown the active service use of a light alloy assault boat capable of taking ten men, an N.C.O. and a crew of two. This boat, propelled by an outboard petrol engine developed by the establishment was in its latest form highly manœuvrable and capable of speeds of more than 15 knots. The use of light alloys was further shown by sections of a floating bridge, the pontoon sections of which were quickly and easily prepared for launching and simply coupled together by means of only four pins when afloat.

For ferrying heavy equipment a new form of sectional raft built up of pontoons and propelled by four hydraulic jet engines was one of the recent developments of the establishment which was demonstrated. This raft with a hydraulic propulsion unit at each corner is highly manœuvrable and is complete with hydraulically operated landing ramps which can be folded back on the deck during movement. The development of bridging equipment forms an important part of the work at Christchurch and to provide an effective means of testing new designs a large new test rig has been designed and built. This rig consists of two testing gantries, each capable of applying a distributed or concentrated load of

up to 250 tons on bridge sections up to 35ft wide and 30ft high.

Another important part of the work of an engineer in the event of war is the making of roads and airstrips, and for this reason a comprehensive study has been made of soil stabilisation methods and equipment. In the course of one of the demonstrations, which was held at Somerford Airfield, there was shown in operation a soil-cement stabilisation train. Before the actual work of stabilisation commences test borings are made with mobile earth augers to determine the bearing capacity and suitability of the types of soil within the construction area. When the required strip has then been marked out it is traversed by a stabilising train capable of constructing a pavement 6in thick and 6ft wide at speeds varying between 4ft to 10ft a minute.

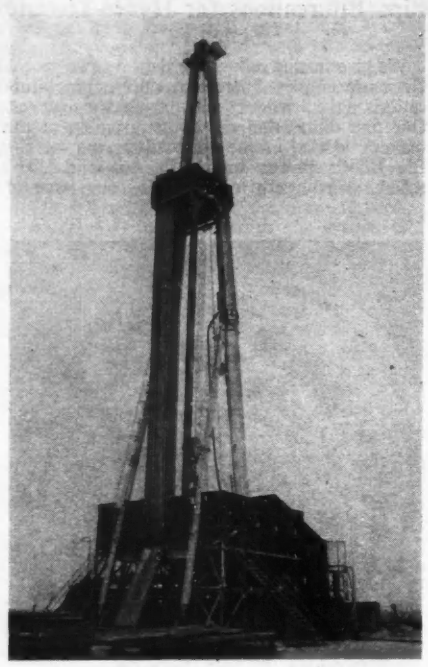
Each train consists of five principal parts—a water tanker, a tractor, a cement spreader-mixer, and a compactor.

The tractor supplies the motive power for the whole train and the drive to the cement spreader and mixing rotor. Cement is fed into a hopper and through a star rotor, which deposits it on the ground just ahead of the mixing rotor. There are eighteen gear settings on the cement spreader to allow for various cement contents and forward speeds which have to be used for the different soils encountered. The water is added by means of a pump which draws it from the tanker and delivers it through a spray bar fitted immediately above the mixing rotor. The supply is regulated by adjusting the pump pressure registered on the dial gauge. The speed of the rotor is 200 r.p.m. and the depth of cut is controlled by raising or lowering the mixing box by the two hand jacks. The mixed material is levelled off by the compactor feed rotor and a screed which is also adjustable for depth, and it is then compacted by six 500 lb reciprocating weights, which fall, in turn, at one second intervals.

Following the soil stabilisation demonstration the visitors were taken to Hurn to see a selection of other equipment specially designed and adapted to military requirements. This plant included water purification sets, mobile workshops, pumps, lighting equipment, air compressors, automatic jerrycan filling machines, &c. The heavy equipment shown in operation included mobile stone-crushing plants, tar macadam mixers, a road-laying machine, crawler and wheeled tractors and motor graders.

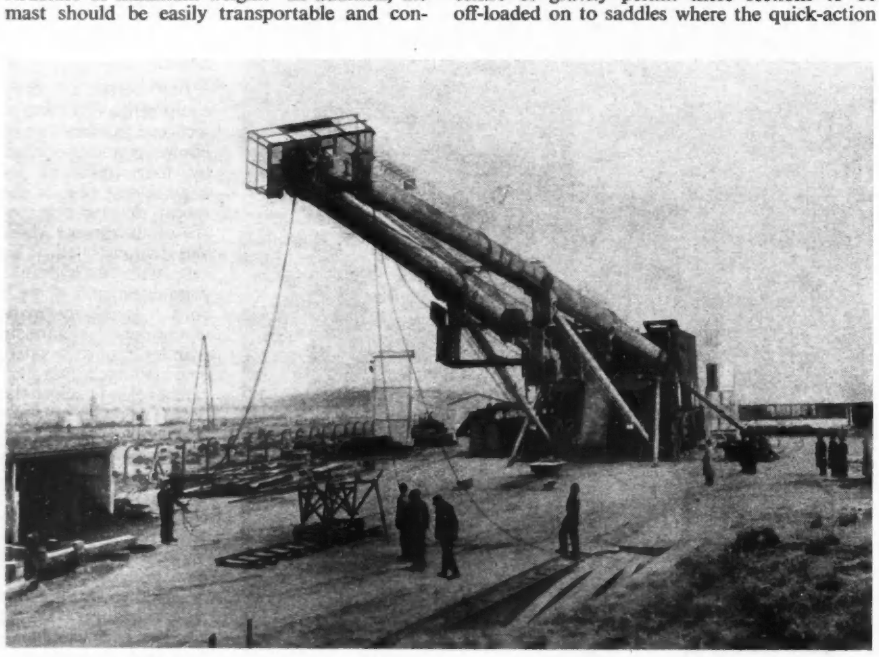
Lightweight Deep-drilling Mast

THE structural problem in the design of drilling masts is to provide a rigid and wind-resisting structure of minimum weight. In addition, the mast should be easily transportable and convenient to assemble. Our illustrations show a design built to these requirements by Salzgitter Maschinen A.G., Salzgitter-Bad, German Federal Republic. The mast stands 138ft high on a 15ft substructure, and has a load capacity of 29½ tons at the crown, or 23 tons at the hook. The racking platform at 84ft level has room for 7200ft of 6⅝in diameter drill pipe and 20,000ft of 3½in diameter drill pipe. An electrically adjustable casing stabbing platform as well as a drill collar racking platform are mounted to the rear of the mast.



Complete drill rig in operation. Access to the racking platform is through the legs. 27,000ft of drill pipe may be stored on the platform

Rigidity is provided by the tubular construction of the two main legs, which are of 0·2 per cent carbon steel. Joined at the top by the crown block, the legs are in three sections, each about 43ft long and 3ft 9in in diameter. Tong counterweights, slush standpipe, ladders and mast lighting wires are all mounted internally, access to the platforms being by automatically closing doors. The mast may be carried in two loads of three sections on a transporter. Lifting lugs at the centre of gravity permit these sections to be off-loaded on to saddles where the quick-action flanges are bolted up. With the help of mounting channels, the ends of the legs are then pulled up on to the pre-assembled substructure, and the mast is raised and locked by struts. Four guy lines secure it against wind pressure.

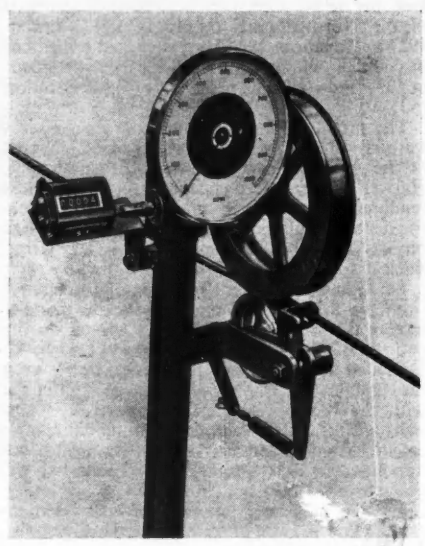


Tubular deep-drilling mast being raised after legs have been assembled and bolted to substructure

Measuring Machine for Extrusion Plant

To provide an accurate measuring machine for use in the electric cable, rope, rubber and plastic extrusion industries, B. and F. Carter and Co., Ltd., Albion Works, Bolton, has introduced a pillar-mounted measuring machine which is complete with a tachometer for registering the linear yards per minute.

The machine, as can be seen in the illustration, is mounted on a pillar which can be of any suitable height to allow the free passage of the material to be measured between the measuring wheel and the spring-loaded jockey wheel. The machine is fitted with a 1 yard circumference measuring wheel consisting of a thin hardened steel tyre stretched over a layer of sponge rubber. This construction provides a resilient surface to the wheel, thus presenting a flat to the material to be measured and minimising the possibility of slip. The resilient measuring wheel requires very little tension upon the material to be measured, it is stated, and eliminates any possibility of damage whilst allowing very high measuring speeds to be obtained.



Pillar-mounted measuring machine for extruded materials

The resilient measuring wheel spindle is mounted on ball races and drives an "Albion" five-figure revolution counter with a roller zero setback motion to record in either feet or yards. In addition, a tachometer is provided to register the linear speed in yards or feet per minute. This speed check is of value where it is necessary to check output to ensure that the parent unit is operating at the desired speed.

EXHIBITION OF DIESEL ENGINES.—Recently Davey, Paxman and Co., Ltd., held an exhibition of diesel engines in London at Montague Place, Portman Square, and Upper Thames Street. The units, which were mounted on two trailers, consisted of examples of the Paxman Mark R.P.H. vee engines having a bore of 7in and a stroke of 7½in. Four, six, eight, twelve and sixteen-cylinder models were on view, and these covered a horsepower range of 130 to 830 b.h.p., all the engines having only one size of cylinder. The four, six and eight-cylinder engines have balanced shafts to eliminate secondary vibration. This range of engines are intended for rail traction, oil well drilling rigs, marine and industrial purposes and, in addition to having the same bore and stroke, have a number of parts in common. This arrangement means a reduction in the number of spares required to be held in stock, and also that an assembled group consisting of a piston complete with rings, gudgeon pin, connecting-rod, big-end bearing, &c., can be fitted to any of the engines in the range. As designed the Mark R.P.H. engines are particularly suitable for users employing a number of power units because of the overall economies effected by the interchangeability of parts.

An Experimental Turbo-Diesel Locomotive*

By F. L. PICARD†

THE free-piston gas generator (the idea for which originated with the work of the Marquis de Pescara in 1924) had, by 1949, reached a state of development that engendered the highest hopes for its applications on land and sea ; hopes which have subsequently been justified.

The author's company then decided to examine the possibilities of this new prime mover in locomotives, in association with a mechanical transmission that would allow full use to be made of the torque-speed characteristic of the turbine.

For this purpose the type 507 turbo-diesel locomotive‡ had been constructed, which is not to be considered as the prototype of a service engine, but as an experimental engine intended to verify a principle and open the way to future studies.

For this purpose the author and his company had confined themselves to modifying a locomotive of the company's own make in order to replace the diesel engines by a gas generator and a turbine, its output being thereby limited to 1000 h.p. and the driving of all the auxiliaries had been entrusted to a 100 h.p. diesel engine.

Briefly, the locomotive consists of a " GS.34 " type gas generator feeding a gas turbine. The latter, provided with a 1/6·15 reduction gear, is mechanically connected to the four axles of the engine through shafts with universal joints and a gearbox including a reversing and change-speed gear. The gearbox, having two ratios which can only be changed with the locomotive stationary, was designed to make the locomotive suitable for both low-speed work (for heavy hauling) and higher speeds.

The objective was an installation of extreme simplicity, such that in normal operation the driver would have to handle only the throttle lever. This elimination of a gearbox to be controlled while running appeared to be possible owing to the high torque of the turbine at low speed. However, it will be seen that this hope has not been entirely justified.

The development of the locomotive has progressed by stages marked by results, improvements and incidents to which the author referred in approximately chronological order.

TESTS CARRIED OUT ON THE EXPERIMENTAL ENGINE

Bench tests were run during 1951 on the gas generator turbine set. At the beginning of 1952 this set was mounted on the locomotive, which did its first track run on March 19, 1952.

As regards fuel, gas oil was used in the early tests along the Paris–Granville line, which were required for the adjustment of the various engine auxiliaries—that is, the circulating system of the cooling liquids, fan, &c. After a few trips the engine was provided with the accessories required when using the fuel intended for it, namely, light-grade fuel oil.

This residual fuel has no counterpart in Great Britain, where it would be classified between groups A and B of industrial heating fuels.

The development of the fuel-oil circulating system (filtering and heating) has been a delicate affair and it was necessary to make alterations several times, some of them major ones.

The heating of the fuel oil to a temperature of 60 deg. Cent. (140 deg. Fah.) was originally done by using the heat in the exhaust gas from the auxiliary diesel engine. This had the advantage of requiring only one grade of fuel for the gas generator ; but, on the other hand, it had the following disadvantages :—

(1) A long starting period, as it could not be completed until all the circuits had been warmed up, including the injection pumps.

(2) Great difficulty in properly regulating the fuel temperature.

(3) Starting the gas generator in very cold weather, with cold fuel in the pipes between pumps and injectors, while it was not impossible, was not to be recommended.

The method of preheating was, therefore, completely altered.

The gas generator is started on gas oil, the fuel oil being warmed by means of the cooling water of the gas generator. About a quarter of an hour is enough to bring fuel oil to the optimum temperature, and during this time the locomotive is serviceable.

Before being stopped for a long time the gas generator is run on gas oil for about two minutes so that the pipes are full of this fuel up to the injectors, which provides for the next start. As regards short stops, the thermal inertia of water, fuel and gas generator allows for starting directly on fuel oil.

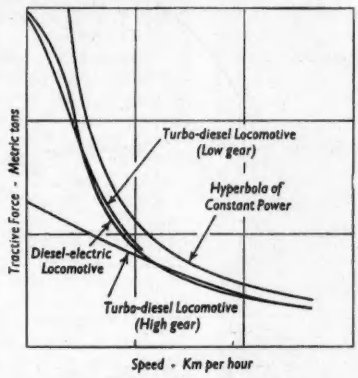
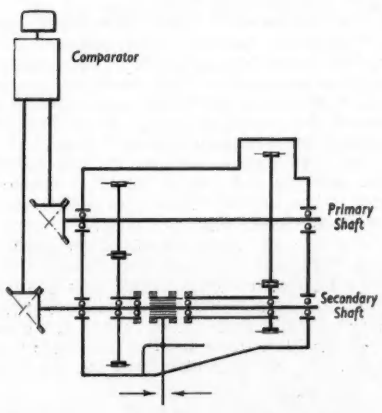

Tractive Force - Metric tons
Turbo-diesel Locomotive (Low gear)
Hyperbola of Constant Power
Diesel-electric Locomotive
Turbo-diesel Locomotive (High gear)
Speed - Km per hour

Fig. 1—Comparison between a diesel-electric and a 2000 h.p. turbo-diesel locomotive

Warming with water gives a temperature steady enough in practice, and the author and his company are completely satisfied with this arrangement. For future development, however, they look to the possibility of attaining an identical result without using gas oil, to avoid the necessity for two fuels.

On the other hand, to allow the locomotive to be started even in cold weather—that is, with the temperature below −5 deg. Cent. (23 deg. Fah.) when gas oil loses its fluidity, it was found necessary to fit every fuel pipe with a water pipe, from the tank strainer through the fuel feed pump and filters to the injection pumps. This comparatively complicated arrangement was fully justified during the winter of 1953–54. Though the cold was severe (−15 deg. Cent. (5 deg. Fah.)) the locomotive was never in the least difficult to start ; fuel oil would be in use twenty-five minutes after starting, despite overnight stops in an open depot in Cambray (Nord). The service given by this engine during this cold spell was decidedly better than that of steam locomotives.



Control is operated electro-pneumatically after synchronism has been detected by comparator.

Fig. 2—Gearbox

The first alterations that showed themselves to be necessary, in the course of the first trips over the Paris–Granville stretch, were those with the object of quickening the response to the driver's control. Whereas a comparatively long delay in increasing the power is tolerable, it is not at all the same thing when decreasing the power ; the load must fall to zero in a very short time, for safety. It was necessary to meet this requirement without interfering with either the stable running or the idling fuel consumption of the free-piston gas generator. The necessary alterations were principally aimed at increasing the rate of discharge of the air spaces in the gas generator to make the pressures fall rapidly. Now full load can be reached in less than ten seconds and power can be completely cut off in just over one second.

In the course of these development tests on the track, some performance measurements with a dynamometer car showed that the results were in agreement with, and even very slightly superior to, the data forecast from the bench tests of the power unit, except for the starting tractive force which had been over-estimated.

The time required by the gas generator to reach a steady working condition supplies a first explanation of this finding. Actually, when this engine is taken rapidly from idling to full load, the pressure, and particularly the temperature, of the gas delivered, require one to two minutes to reach their final values, during which time the turbine gives a slightly reduced output.

Later on, during tests on the Vitry locomotive test bench, a second hypothesis was evolved : the heavily loaded rubbing surfaces in the mechanical transmission between the turbine and the wheels (gearbox, driving axles, &c.) have higher coefficients of friction when the locomotive is being started (static state) than when running (dynamic friction).

Though both these phenomena did not represent a big loss, they were enough to bring down the performance below what was expected.

In consequence, it was decided to fit the gas generator with an overload device that enables the driver, in case of need and only during starting, to increase the output of the gas generator, and hence the torque of the turbine, by about 15 per cent.

This modification brought about a substantial improvement in the engine.

It was also possible to appreciate during these preliminary tests the great importance of the fuel consumption when idling. Though the specific consumptions from the bench tests were just above those of the diesel engine, high daily fuel consumptions were recorded owing to long periods of idling.

The author therefore set about adjusting the consumption of the gas generator to the minimum compatible with stable running and quick response. By a series of improvements leading to a reduction of pressures and speed of oscillation, it was possible to cut down idling fuel consumption from 75 kg to less than 40 kg per hour (from 165 lb to 88 lb per hour). Of course, this figure is still higher than that of a diesel engine of the same power, but less than that of orthodox gas turbines, which are at a particular disadvantage in this respect.

These tests also yielded some information about the transmission system.

On two occasions the turbine was brought to a sudden stop, the first time following a roller bearing failure in the gearbox, and the second time as a result of the driver's inadvertently changing into reverse while the turbine was still running. These two abrupt stoppages developed severe inertia torques in the transmission system and the end of the shaft emerging from the turbine reduction gear was twisted, without any other part of either the turbine or reduction gear being damaged.

It became clear that it was necessary to provide the transmission system with a component of reduced strength and easy to replace (in this instance shearing bolts), designed to break at a torque just above that of the starting torque, in spite of drawbacks that might be associated with it.

Likewise, it was essential to fit the engine with a safety device to make it impossible to move the reversing dogs while the turbine was still rotating or the locomotive running.

Tests on the Vitry Locomotive Bench.—When these tests on the track were completed, a series of performance tests were undertaken on the locomotive test bench of the Société Nationale des Chemins de Fer Français at Vitry.

* Paper presented to the Institution of Mechanical Engineers, April 22nd. Abridged.

† Directeur des Études et Recherches, Régie Nationale des Usines Renault, Billancourt, Seine, France.

‡ " Turbo-diesel " indicates a locomotive powered by a free-piston gas generator/turbine set.

Scheduled Service and Endurance.—Expectations having been confirmed by these locomotive bench tests, the machine had still to face an endurance test. The French National Railways reserved an express run with a moderate amount of traffic for the experimental engine on the Paris–Cambrai line, with a daily departure from and return to Paris, which made it easier to follow its behaviour in service.

Some particulars of this run are given in Table I :

TABLE I—*Particulars of Scheduled Run*

Date of entry into service	April 15, 1953
Daily mileage	400km (250 miles)
Maximum speed	110km/hr (68 m.p.h.)
Duration of run	6 hours
Hauled load	160–200 tons

The results obtained are very encouraging : the locomotive has run 105,000km (65,250 miles) during the first year and 140,000km (87,000 miles) up to September 1, 1954.

The measured fuel consumption decreased from the beginning as a result of continuous adjustments. In the early runs the average consumption for 100km (62 miles) was 240 kg (529 lb) of light-grade fuel oil, and 48 kg (106 lb) of gas oil, of which 25 kg (55 lb) were for the auxiliary engine and 23 kg (51 lb) for starting the gas generator. Ajustments to reduce idling fuel consumption, together with the training of the operating staff, enabled the fuel oil consumption to be reduced to less than 180 kg (397 lb) per 100km (62 miles), while improvements in the fuel heating circuits reduced the average quantity of gas oil necessary for starting from 23 kg to 13 kg per 100 km (28 lb per 62 miles).

Perhaps these figures may seem rather high, but it should be remembered that they represent monthly averages of total fuel consumption, including the fuel consumed while travelling between the depots and the stations, although these runs are not counted in the total distance used in calculation of the averages.

In analysing the various incidents that marked this sixteen months of service, the author would not mention the troubles that might have occurred with standard components of a locomotive, such as the air compressor, fan, &c., or those related to minor components of the gas generator or turbine, which were of no particular interest.

First, it should be mentioned that the turbine was perfectly reliable, as shown by a total absence of troubles and negligible maintenance. This sturdiness swept away all the fears entertained at the start of the project, in regard to the behaviour of a turbine mechanically coupled to the wheels of a locomotive.

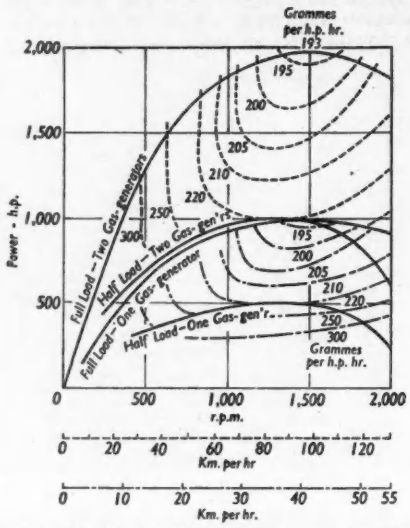
After having been adjusted on the Vitry test bench, as mentioned above, the only observations made on the central gearbox referred to points of detail on the controls up to the 142,000th km (88,000th mile) when a fault in the operation of the controls caused failure of the reversing dogs which were only partly engaged. A modification of the control fork, will prevent a recurrence of a similar incident.

The gas generator, being the principal and least orthodox unit in the locomotive, would naturally be expected to have, if not the greatest number of troubles, at least the most serious ones.

In November, 1953, when the gas generator had run about 1600 hours since its last general overhaul, attention was drawn to an abnormal rise in the cooling water temperature. From then on this fault grew worse, and gas bubbles appearing on the water caused the gas generator to be stopped by the safety devices.

On dismantling, a crack was observed in the central ring (the part of the diesel cylinder that carries the injectors and to which the two cylinder liners are attached) and this the maker traced to a faulty gasket on one of the precombustion chambers.

It should, however, be mentioned that the gas generator fitted in the locomotive was the sixth



The fuel used is light-grade fuel oil. If gas oil is used consumption is reduced by approximately 5 per cent.

Fig. 3—Curves of power against speed and constant specific fuel consumption for a 2000 h.p. turbo-diesel locomotive

unit of the type GS.34, and that, when it was delivered, the manufacturer had had experience practically only with the prototype. Since then progress has been made and, in particular, the central ring has benefited by improvements dictated by experience acquired on more than sixty engines in service. Several types of central ring have been tested. The one on the experimental locomotive was of the first type, and the author was not surprised by this failure. The latest central rings tested by the manufacturer have run for a very large number of hours without trouble, which leads to the view that this fault will not occur again.

During the same overhaul it was found that the compressor suction valves were fouled, which had never occurred in other applications of these gas generators. It was therefore reasonable to think that it was due to the readmission of part of the exhaust gas leaving the turbine, at least when it was running in one direction. This idea was reinforced by the fact that the valves at the scavenge end (whose intake is situated nearest to the turbine exhaust gas outlet) were more severely fouled than the others.

In consequence, the positions of the intakes (on the sides of the canopy) were changed, and since then this effect has practically disappeared.

It had also been observed that the compressor delivery valves became fouled, as well as all the walls of the scavenge casing, but the cause was different. In this instance it was the breaking up (cracking) of lubricating oil carried along by air from the compressor cylinders in contact with hot areas of the scavenge casing. This problem was solved by the use of a detergent oil for lubricating the cylinders.

In May, 1954, when the locomotive had run over 110,000km (68,000 miles), there were fresh incidents with the gas generator, caused by breaking of diesel piston rings. These breakages, which are rather unusual in the other applications, have not yet been satisfactorily explained. Nevertheless, it was known that since the November incident the diesel cylinder liners were abnormally and irregularly worn, probably owing to water leakage through the crack in the central ring. At the time, these liners had not been replaced, and it is considered that the piston-ring troubles are to be traced to the cylinder liners being worn.

Various schemes for improving the condition of the piston rings are being tested with new cylinder liners. In October, 1954, the gas generator was thoroughly overhauled to give it the benefit of the numerous improvements made on these engines since the start of development. These tests will make it possible to draw more definite conclusions, since a closer watch will be kept on these components.

CONCLUSIONS DRAWN FROM EXPERIMENTS

All the findings during the course of the service running of this experimental engine led to certain conclusions which now serve as a basis for the study of future models.

The first of these conclusions concerns the tractive force when starting, which, from the beginning of the tests, has been less than was expected. As already mentioned, alterations made it possible to exceed the figures hoped for, but it is evident that, if the engine is usable in this form, it does not allow full use to be made of the available power.

In service, the hauled load is deliberately reduced to avoid any risk of experiencing difficulties when starting under difficult conditions (on a slope or a turn). To be sure, low gear will always make extrication from difficulties possible, but the necessity of staying in this gear till the next stop is not always compatible with service requirements, and does not favour a good fuel consumption.

On the other hand, the value of the tractive force at low speeds is lower than that obtained with other types of locomotive and proportionately reduces the acceleration.

For these different reasons it appeared necessary to envisage change of gear while running, on future machines. Calculations have made it possible to determine the optimum ratio to be provided between the two gears to obtain the best acceleration and consumption.

Fig. 1 shows that the curve of tractive force of a locomotive fitted with such a gearbox lies practically on top of that of a diesel-electric locomotive of the same power and is very little different from the hyperbola of constant power. It can also be seen that the maximum tractive force when starting is greater than the adhesion.

Different systems for changing gear while running have been considered, and they are now being tested on the experimental engine.

The first solution, which may be called an orthodox one, has a clutch before the gearbox (Fig. 2), as in a motor-car. A special patented

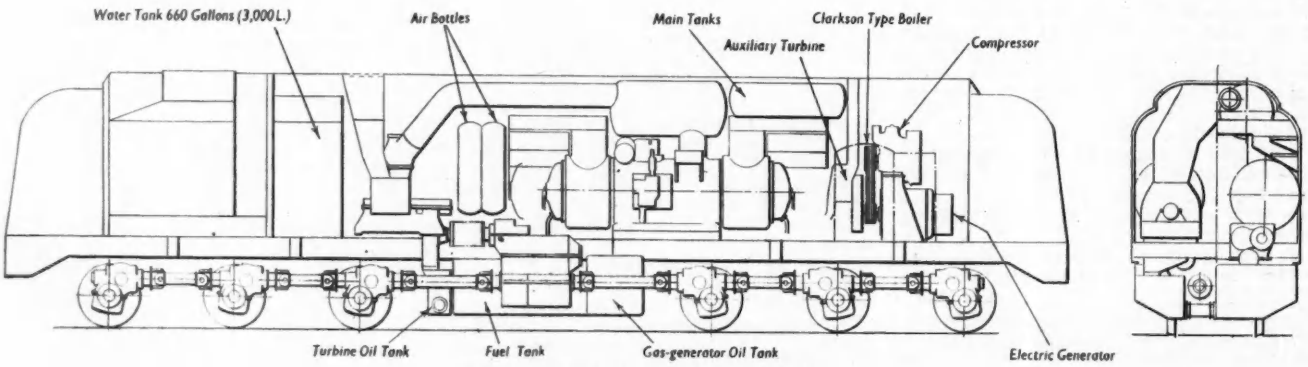


Fig. 4—Turbo-diesel locomotive of 2000 h.p.

device called a "comparator," already used by the author's company for the gearboxes of diesel locomotives, allows the dog clutch to be actuated at the exact instant when the gears come into synchronism. For this purpose, provision is made for braking or accelerating the turbine, according to whether the gear ratio is changed up or down.

In a second solution, which is also mechanical but appreciably more expensive, the dogs are eliminated. It consists essentially of epicyclic gear trains and a separate clutch for each gear ratio.

Finally, a third solution has been considered, mechanical in first gear to profit by the high torque of the turbine at zero speed, and hydraulic in second gear. This arrangement offers some advantages, but with the drawback that it introduces losses due to the hydraulic coupling into the most frequently used gear.

The second conclusion from these tests is concerned with the relative importance of the cost of the fuel consumed by the auxiliary engine in the running cost on account of the high cost of gas oil (43 French francs per kilogramme against 15 francs per kilogramme for light-grade fuel oil). Driving the auxiliaries by the gas generator would considerably reduce the fuel cost. Since from its construction the gas generator had no rotary power take-off and was, therefore, incapable of providing such a drive directly, and since the turbine rotated at a very variable speed, which might in particluar be zero, it was necessary to provide a special turbine.

In a first project the idea of placing a simple turbine downstream from the main turbine had been considered. This solution, which would have the advantage of recovering some of the residual energy in the gas discharged to atmosphere at light loads, and thus of obtaining energy almost for nothing during long periods of running, would unfortunately lead to a very bulky turbine whose governing would be very difficult owing to the huge volumes of gas involved.

The solution consisting in supplying this auxiliary turbine with air drawn from the scavenge casing of the gas generator or gas generators was preferred.

In fact, it is always possible, and even advantageous, to draw off air from this casing at low power. It is not the same thing at high power, but tests have shown that a small amount can be drawn off without any effect at all on the quality of the combustion in the gas generator. This arrangement allows consideration of a design of turbine of small dimensions running at high speed, whose governing device (butterfly or valve) is easy to control.

The elimination of the auxiliary diesel engine will also bring about a substantial reduction of the noise produced by the locomotive. In fact, measurements have shown that one of the principal sources of noise was this engine running continuously at full load, even with the gas generator idling.

Fortified by this experience acquired from a scheduled service of over 140,000km, the author and his company had undertaken, in collaboration with another company, the design and construction of two types of turbo-diesel locomotive, which are briefly described below.

New Developments

Locomotive of 1000 *H.P.*—Designed with a view to its application to railway systems of new countries in the course of development, this locomotive can pass through the usual templates of the metric track railways. The frame is arranged in such a way that the narrow bogies can be replaced by normal or even broad track (Russian or Spanish) bogies. Similarly, the buffers and couplings can equally well be those for metric, normal or broad tracks.

This engine is characterised chiefly by: (1) a mechanical transmission with two gears changeable while the engine is running; (2) auxiliaries driven by compressed air turbine fed with air drawn from the free-piston gas generator. This turbine drives the cooling fan, a service air compressor and a 65kW alternator which drives all the other auxiliaries electrically. The main turbine provides its own oil circulation.

Locomotive of 2000 *H.P.*—This engine, which can be adapted to normal or broad track, is derived from the 1000 h.p. locomotive. It comprises two gas generators and two turbines.

Each turbine drives a bogie with three driving axles, through a mechanical transmission system with two ratios changeable while running, the three driving axles being driven in series by a single transmission shaft.

The engine is designed for the two kinds of service, passenger and goods.

When service requirements permit, it is possible to stop one of the gas generators and run with only one set, which gives a better efficiency to the gas generator turbine unit, which then operates closer to its full load condition (Fig. 3).

Fig. 3 shows the total power output from the output shafts of the first reduction gear plotted against the speed of these shafts, together with lines of constant specific fuel consumption. It is shown that by stopping one of the two gas generators a good specific fuel consumption can be obtained (less than 250 grammes per horsepower-hour of fuel oil, or 0·56 lb per horsepower-hour) from 18km to 130km per hour (11 to 81 m.p.h.) and from 450 h.p. to 2000 h.p.

The auxiliaries are driven in the same way as in the 1000 h.p. engine, by an auxiliary turbine receiving compressed air from the gas generators, and driving an alternator which drives the auxiliaries.

The main turbines provide their own oil circulation.

In Fig. 4 this engine is shown diagrammatically. Its numerical data are as given in Table II.

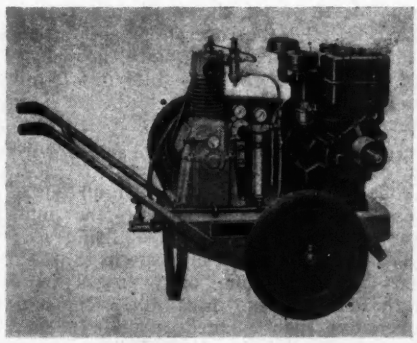
Table II—*Numerical Data of* 2000 *H.P. Locomotive*

Overall length	19·2m (63ft)
Overall breadth	2·85m (9ft 4in)
Maximum height	4·2m (13ft 9½in)
Maximum speed :	
Low gear	57km/hr (28 m.p.h.)
High gear	127km/hr (79 m.p.h.)
Weight	108 tons approximately

Small Portable Air Compressor

A small portable diesel-engine-driven air compressor, with a displacement of 14·4 cubic feet per minute, is a recent addition to the range of pneumatic equipment made by B.E.N. Patents, Ltd., High Wycombe, Bucks.

As can be seen from the accompanying illustration, the new machine consists of a steel plate



Diesel-engine-driven air compressor

frame mounted on pneumatic wheels, and carrying a compressor driven by a small diesel engine. The engine is a 3½ h.p. Lister diesel, complete with 1½ gallon fuel tank, and controlled by an adjustable pneumatic governor. It drives through twin vee-belts a single-cylinder, 3½in bore by 4in stroke compressor, from which the air is delivered into twin tubular receivers. Air is supplied through a pressure-reducing valve for working two tools at pressures from 20 lb to 80 lb per square inch. A coiled copper aftercooler works in conjunction with a fan flywheel to give effective cooling, and an oil and moisture separator is fitted.

Road Bridge in Uganda

The accompanying illustration shows an N-braced steel truss bridge whch spans the Kazinga Channel between Lake George and

Bridge over the Kazinga Channel, Uganda

Lake Edward, in the Queen Elizabeth Park in Uganda. The bridge originally formed part of an emergency bridge built across the Thames in London during the war. After the war ended, the bridge was demolished and was recently re-erected to form two road bridges in Uganda, one of which is shown here. The Kazinga Channel experiences swift flows, and the Public Works Department, who erected the bridge, had to build the approach embankments swiftly to avoid damage due to scour.

Standard Building Designed According to the Plastic Theory

A single-storey storage building, which forms part of a range of standard steel buildings made by Sanders and Forster, Ltd., Hertford Road, Barking, Essex, introduces various simplifications in its design and construction. It has been designed according to the plastic theory recently developed for steel structures, which is now finding increasing application in structural practice. A reduction in weight over the more conventional elastic design methods is thus possible, and further simplifications in detailing have been introduced.

The building may have a span of 30ft, 40ft, 50ft, or 60ft, and four wall heights from 11ft to 20ft to the eaves may be used. The main frames are spaced 20ft apart. The stanchions consist of plain lengths of rolled steel joists, drilled, but without caps or bases; they are erected in pockets left in the concrete base, and are concreted in after the building has been levelled and plumbed. The roof of the building is shallowly pitched; each main portal frame comprises a pair of stanchions with a pair of rolled steel joists forming the roof shape, with bolted connections at the ridge and eaves. The frame is completed by ½in diameter tie rods; the principal tie passes between the stanchion heads horizontally, and there are vertical ties connecting it with the roof joists at the ridge and at the quarter points. There are also tie braces in the plane of the walls. The purlins consist of 4in. by 1½in joists, attached to the portals by pressed steel cleats, which are designed to give a high degree of continuity. The purlins are connected in the plane of the roof by sag rods which hook into one another, thus eliminating threaded ends and nuts. The various tie rods have turnbuckles which give a quick method of "squaring up" the building. Various forms of roof and wall covering, and of building accessories can be used with this basic steel frame.

The American Scene

BY OUR AMERICAN EDITOR

GUIDED MISSILES

In accordance with the commendable practice of the American armed Forces of declassifying the main features of such new weapons as guided missiles, the U.S. Air Force recently released certain interesting information concerning its latest air-to-air missile, the "Falcon." This important weapon is the result of a development project which required six years and the employment of more than a thousand men. The Air Force has described the 6ft "Falcon" as "the only air-to-air missile with a brain of its own" and now considers it as the first line of defence against air attack. It is claimed that once the enemy bomber has been pointed out to it, the electronic brain of this missile will steer it to anticipate and strike this target no matter how the bomber should manœuvre. It is expected that the "Falcon" will be supplied as armament to all-weather fighter interceptor aircraft of the U.S. Air Force shortly. This and other developments in the field seem to indicate the approaching maturity of the missile age, which usually is considered to have started with the German "V1" and "V2" bombardment of London. Two cruisers of the U.S. Navy have been under conversion to guided missile ships and will be commissioned this year, equipped with the beam-riding "Terrier," an anti-aircraft missile. The U.S. Army is equipping its troops with the "Corporal," a surface-to-surface bombardment missile capable of carrying an atomic warhead for more than 75 miles. The "Honest John" free-flight artillery rocket is already in service with U.S. Army troops in Germany. The U.S. Air Force operates the tactical missile "Matador," a pilotless aircraft, and the U.S. Navy has a counterpart in the ship-launched or submarine-launched "Regulus." The "Nike, a slim, pencil-pointed missile which has a range in its first version of 20 to 30 miles, is now being placed in position around many American cities. The anti-aircraft guided missile is now assuming the burden of the point defence of important targets, and the "Sparrow," the "Falcon" and other air-to-air guided missiles, with ranges measured in a few miles, are beginning to displace aircraft guns in aerial warfare.

Functionally, there are four principal kinds of missiles: surface-to-air or anti-aircraft missiles, air-to-air, air-to-surface and surface-to-surface missiles. Missiles may be further classified as those designed for use against moving targets and those designed for use against fixed objectives. The guidance systems being used include the so-called beam-riding type, which "climbs" up an electronic or light beam toward a target; the homing type; the command guidance type controlled from ground, ship or aircraft; and the automatic navigation type, which has many variations. A pre-set missile, i.e. a missile which has its own propulsion system, but the course of which cannot be changed once it is launched, is not really guided; it is a "free-flight" vehicle, like the "Honest John" 762mm field artillery rocket of the U.S. Army. The propulsion systems of guided missiles are of infinite variety. Most of the fuels known to Nature have been experimented with and include even powdered metals, dyes, alcohol, acids and liquid oxygen, petrol and various kinds of powder. Rockets powered by liquid and solid fuels, and various forms of jet engines provide the power for to-day's missiles; nuclear power for missiles has had relatively little attention, since the use of nuclear fuels in a one-shot weapon like a missile would be exceedingly wasteful and expensive. In the first instance, as expected, the guided missile art has produced anti-aircraft weapons which are now strengthening the air defence of the United States. The "Nike" and the "Terrier," within their limits of range and against targets flying under 50,000ft, are accurate and deadly, though not, of course, infallible. Their range is their weak point; if an enemy bomber is able to approach within 35 miles of New York City, a hydrogen bomb or even a large atomic bomb dropped on the outskirts might well wreak havoc in the vicinity. These range deficiencies are being remedied, however. In the surface-to-surface field missiles like the "Corporal" and its longer-range successor, the "Redstone," are accurate, supersonic and, once launched, almost impossible to stop. Both these missiles still have some "snags," but these are being eliminated. At longer ranges, above 150 miles, the "Regulus" and "Matador" are reliable and simple and are fairly accurate if they can be guided by accompanying aircraft or by intermediate ship-based or shore-based radar stations throughout their flight range of 500 miles. But they are subsonic missiles; they travel in level flight, and if guidance is confined to the point of launching their accuracy above 150 miles is speculative. In the air the first results of a decade of research are air-to-air weapons, like the Navy "Sparrow" and the Air Force "Falcon." These are essentially small rockets, which, however, can be guided in flight by the pilot of the launching aircraft. The new interceptor of the Air Force, the "F-102," is scheduled to be equipped with "Falcons." To date, therefore, the development of the guided missile in the United States has been of considerable value in the field of anti-aircraft defence, except in those cases where an enemy possesses missile launching sites within approximately 200 miles of the objectives to be defended. This same development, however, has complicated greatly the operations of ground armies. There is, for instance, no defence against the "Corporal" with its 75-mile range, except to destroy it before it is launched.

What is the outlook for future guided missile developments in America? In its ultimate form, the "dean" of all guided missiles is considered to be the inter-continental missile, capable of flying accurately across oceans at high speeds to targets and carrying atomic or hydrogen bomb warheads. Three of these—each more superlative than its predecessor—are under development in the United States: the "Snark," a pilotless aircraft with trans-oceanic range and high subsonic speed; the "Navaho," a pilotless aircraft with trans-oceanic range and supersonic speed, and the "Atlas," a ballistic guided missile capable of crossing the ocean in minutes. Some of these missiles will probably be operational within the next three to ten years. Improved anti-aircraft and air-to-air missiles will also be produced during that period and, theoretically, it may even be possible at some time in the future to produce a missile-hunting missile which could intercept an "I.B.M." (inter-continental ballistic missile). But this, so far, is theory. In the light of present knowledge it seems clear that the next chapter in American guided missile development will aid the offence, just as the first chapter aided the defence. When the "I.B.M." with a thermo-nuclear warhead is an actuality on both sides of the Iron Curtain, strategy will have been revolutionised. The radar warning systems which are now being built against low-altitude, low-speed missiles and aircraft will be outmoded. The "Nike" will have no usefulness against a rocket plunging in a parabolic curve from the stratosphere at a speed of thousands of miles an hour, with a warhead of sufficient power to compensate for errors of aim. To prevent the launching of such missiles can be the only hope of security in the world of to-morrow. This can be done by deterrents—threatening the enemy with more launching sites and more guided missiles than he can muster—and by political solution of international difficulties.

Federal Reclamation Work During 1954

THE latest annual report of the U.S. Bureau of Reclamation pointed out that construction completed during the year added about 2,200,000 acre-feet of water storage capacity in new reservoirs, 297,250kW of hydro-electric generating capacity, 700 miles of canals, pipelines and laterals, and more than 100 miles of major electric transmission lines. In line with the policies of the Eisenhower Administration, numerous organisational changes were effected in the Bureau to provide greater efficiency and economy in its operations. Particularly, more emphasis was placed on local participation and responsibility at all levels of planning, construction and operation and maintenance of the Federal Reclamation programme. The construction work completed provided irrigation facilities for about 237,000 acres of land, and brought the total of water service provided under the Federal programme to 126 storage and eighty diversion dams, more than 19,500 miles of canals and laterals, more than 5700 miles of drains, 386 major pumping plants, and an estimated 11,300 miles of operating roads. The year under review saw the completion of Canyon Ferry dam, a large concrete dam on the Missouri River in Montana, and the placing in service of its 50MW power plant; the completion of Jamestown dam, an earth dam in North Dakota, nearly a year ahead of schedule; the addition of 104,750kW of power capacity on the Colorado-Big Thompson project in Colorado through the completion of the Flatiron power and pumping plant and the Pole Hill power plant; the "holing through" of the 4·5-mile long Eklutna Tunnel, a major part of the Eklutna project in Alaska, and the placing in full service of the Hungry Horse power station in Montana, which is an important unit in the multiple-purpose development of the water resources of the Columbia River and its tributaries.

Other accomplishments included the completion of the Trenton dam and the Bartley diversion dam, both on the Missouri River basin project in Nebraska, and the construction of irrigation facilities to serve about 55,000 acres of land on the Columbia basin project in the State of Washington. The total value of all contracts awarded in the year amounted to about 60,000,000 dollars, and construction contracts

comprised about 52,000,000 dollars, or about 87 per cent of this total value. In its entirety, the Federal reclamation programme now supplies irrigation water for 125,000 family-sized farms and a like number of urban and suburban units consisting of more than 7,000,000 acres of land on which 410,000 settlers live. This land, which is supplied with water from works constructed by the Bureau, is about one-fourth of the total irrigated land area in the Western United States. In addition to the settlers living on the projects, at least 1,500,000 persons living in nearby towns are dependent on the reclamation programme, while other works of the Bureau provide municipal and industrial water service to another 2,000,000 people.

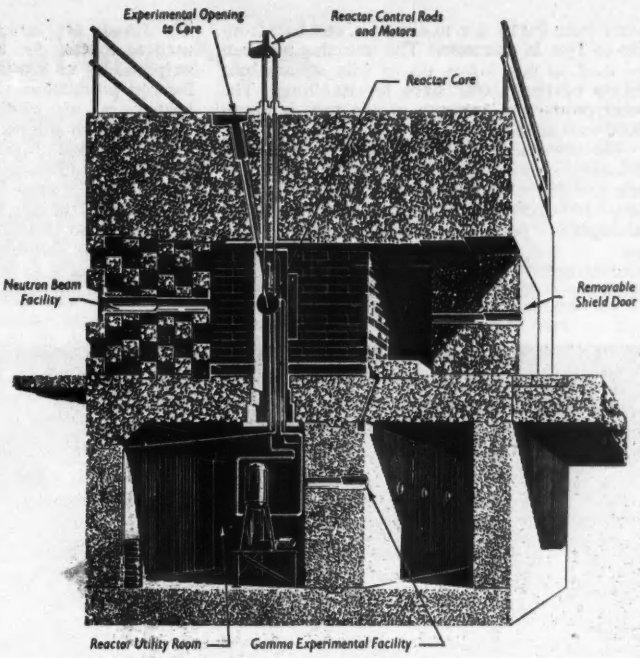
During the 1954 fiscal year, nine land openings conducted by the Bureau of Reclamation on four projects opened for settlement 389 new farm units, totalling 34,126 acres. During the 1955 fiscal year, additional land openings or sales are scheduled on the Columbia basin and Yakima projects in Washington ; the Minidoka project in Idaho, and the Gila project in Arizona, with a few additional farm units being made available on one or more of the other schemes of the Bureau.

Nuclear Reactor for Industrial Research

THE Armour Research Foundation of the Illinois Institute of Technology, Chicago, Illinois, has placed an order with North American Aviation, Incorporated, of Los Angeles, California, for the construction of what is claimed to be the first American nuclear reactor designed for private industrial research. The reactor will be situated on the "campus" of the Illinois Institute of Technology, and construction will begin as soon as the project has been approved by the U.S. Atomic Energy Commission. Fissionable material for the operation of the reactor has been requested from the Commission under the licensing provisions of the A.E.C. Act of 1954. The reactor and ancillary equipment is expected to cost about 500,000 dollars. Scheduled to be completed in about a year, the reactor will be available to industrial and Government sponsors to conduct a variety of nuclear research projects. The pile will be capable of operating at a power level of 50kW and will produce neutrons and gamma radiation for research and development in the fields of biology, metallurgy, food processing, electronics, chemistry, textiles, oils and gases, rubber and leather, machinery, building materials, and allied industrial and scientific pursuits.

The aqueous homogeneous, or "water boiler" reactor, which is shown in the accompanying illustration, will be situated in a room about 48ft long, 72ft wide and 30ft high. Atomic fission will take place in the reactor core, which is a steel sphere about 12in in diameter. The sphere will contain about 4 gallons of uranyl sulphate, enriched in uranium 235, in a water solution. The reactor core will be surrounded by an 8ft by 5ft by 5ft stack of graphite bars, which act as a reflector. The graphite stack is completely enclosed in a steel tank, except for those areas opened to permit access to the radio-activity and neutron supply from the core. Dense concrete blocks about 5ft thick form the exterior shield for the machine, giving an overall dimension of 18ft long by 16ft wide by 11ft high for the shielded reactor structure.

The rate of fission in the reactor will be controlled by four boron rods. An interesting aspect of this reactor is its "self-contained" design, which confined the radioactivity within the shield. No fumes, gases, smoke, or any other materials will be exhausted or discharged from the machine. This design, together with the inherent safety features of the solution reactor, make it particularly suitable for the research programme of the Foundation. Fissionable material to "fuel" the reactor will be obtained from the U.S. Atomic Energy Commission on an "extended loan" basis. The Foundation has pointed out that sponsored research with the machine will be subject to no competition from military applications and no secrecy of any kind other than that called for in the protection of the individual sponsored programmes. It will not be used for research on reactors, or for electrical power generation.

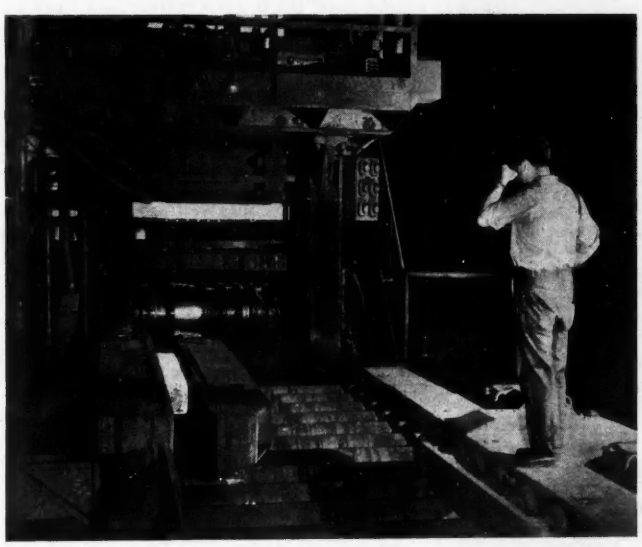


Artist's impression of 50kW "water boiler" reactor to be constructed at the Armour Research Foundation in Chicago

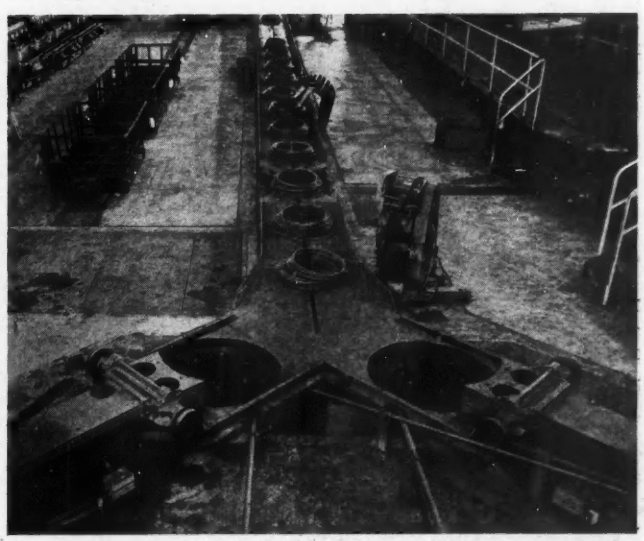
Multiple-Purpose Hot Rolling Mill

THE Carpenter Steel Company, of Reading, Pennsylvania, has put into operation an interesting hot rolling mill which, for the first time in the United States, facilitates the production of strip, rods, and bars on one mechanised combined unit. The new mill was designed particularly to meet the exacting requirements of producing a wide range of specialty steel products, including tool, stainless and alloy steels. In addition to the remarkable production flexibility provided by the plant layout, this multiple-purpose mill incorporates many recent developments in "automation" devices and improved heating facilities which aid in controlling surface decarburisation. All bars produced by the mill are individually cooled on a notched bar cooling bed prior to annealing to help develop a uniform grain structure.

The mill, which covers an area of 125,750 square feet, is equipped with a total of twenty-four mill stands of the following sizes :—10in, 12in and 14in two-high mills, an 18in three-high mill, and a 20in reversing two-high cogging mill. The finished product capacities of the installation include strip stock from ½in to 10in wide, having a minimum thickness of 0·093in, rod coil



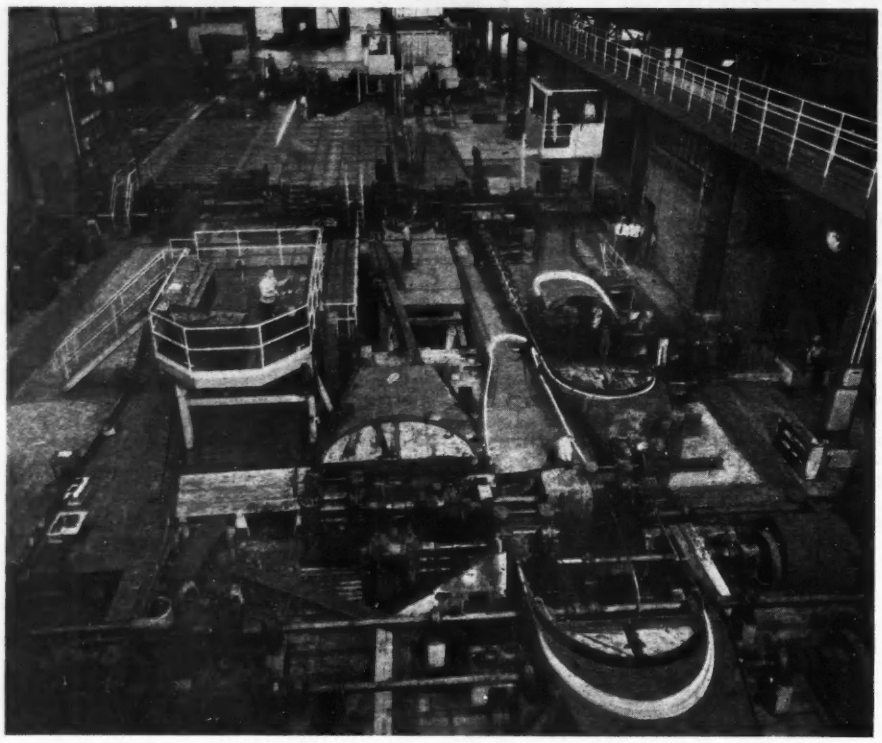
Cogging of ingot on 20in reversing two-high mill



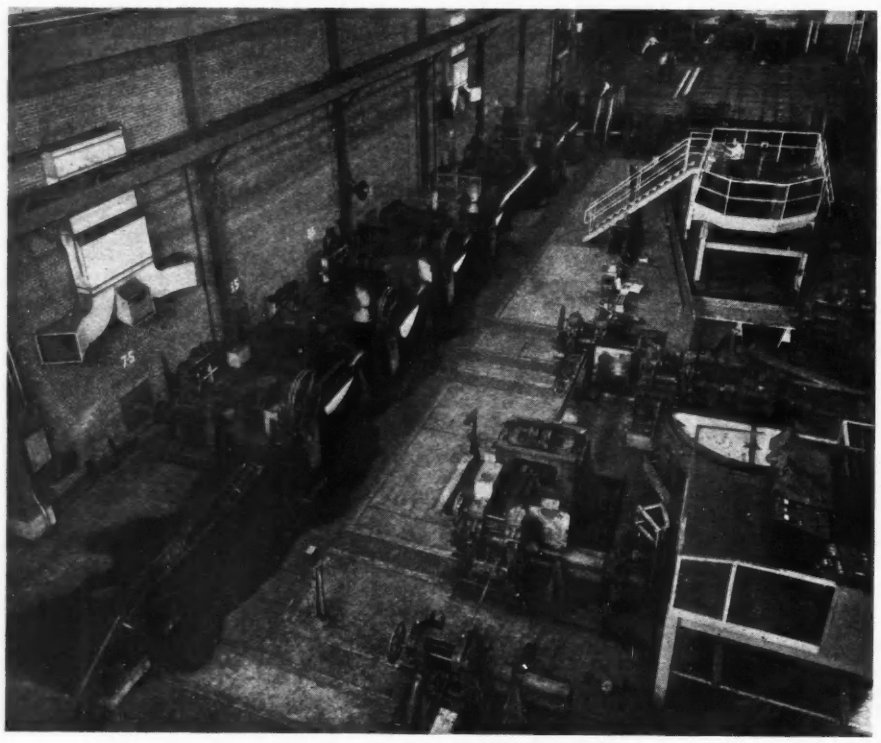
Cooling of rod after leaving automatic rod mill coilers

stock from ¼in to ⅞in in diameter, and bars from ⅜in to 1½in in diameter. The reversing mill can be used to cog ingots up to 14in square into billets or rectangular slabs for rerolling. The total production capacity of the mill is about 3000 tons of specialty steels per month.

The unusual layout of the mill provides five finishing points which facilitate changing the size and shape of the product with a minimum loss of operating time. Furthermore, the arrangement permits rolls to be changed in one part of the mill while operations continue uninterrupted on other stands, thus substantially reducing "down" time during roll changes. The stands are arranged so that they can be used as a train for bar rolling, in tandem for strip rolling or cross-country and loop rolling for rod production. The ingots and billets are heated in an oil-fired, continuous furnace equipped with automatic controls. After leaving the continuous furnace, the ingot enters the initial breakdown mill, being conveyed automatically on a roller table. If the final product is to be strip, the slab from the 20in mill proceeds straight ahead through one 14in strip mill consisting of six two-high stands and one edger. If the product is to be bars or rods, billets from the 20in mill are moved laterally to the three-high 18in mill which is equipped with tilting tables. From the 18in mill, the steel proceeds to a 12in mill consisting of one 14in two-high stand and four 12in two-high stands which are situated side by side and arranged for either cross-country rolling or looping. For still smaller sizes of bars or rods, there are eleven 10in two-high stands arranged for looping. The product leaving the mill can take one of three courses. From the strip mill strip is put through an oscillating feeder and placed on edge on a cooling table and finally coiled. The bars proceed straight ahead to a notched-bar cooling bed and small sections can be led to either of two coiling reels. The completed coils are delivered to a loading point by a conveyor table, each coil moving separately so as to obtain individual cooling.



Finishing of rod on cross-country two-high mills



Rolling of strip on six-stand two-high tandem mill

Separate drives and motors on each stand in the mill permit rolling within a close temperature range from billet to finished product. Full operation of all stands of the mill requires a total of 9500 h.p. To provide smooth and clean hot-rolled surfaces, and to minimise scale pitting, a high-pressure water spray descaling system is used, and scale from the mill is carried to a basin where it settles to the bottom. Clear water overflows into a second basin and is then pumped back into the mill water supply system. This recirculation of the water not only conserves the water supply, but also prevents contamination of the Schuylkill River, which flows alongside the works. The new mill produces material for the company's cold rolling and cold drawing departments, as well as hot rolled products for direct sale. The production flexibility inherent in the mill makes it possible to meet the needs for special size and shape rolling at short notice, and facilitates the economical production of small orders ranging from 1000 lb to 15,000 lb.

Cathode-Ray Memory Tube

AT the recent exhibition of the Institute of Radio Engineers in New York, the Raytheon Manufacturing Company, of Waltham, Massachusetts, demonstrated its "frozen television"—a system capable of capturing the fleeting images on a c.r. tube screen and instantly playing them back in the form of still pictures. The heart of the system is a cathode-ray tube with a built-in memory, which can store one frame of a television picture and "play it back" on a monitor up to 30,000 times. The stored picture, when played back and seen on the monitor screen, has a quality comparable to television, with a full range of grey shades and minute detail. Several models of the tube have been built, and the latest design can store 125,000 bits of information (where a "bit" may be a number, letter of the alphabet, grey shade, &c.) and can hold them for up to a week before playing them back. Furthermore, the whole 125,000 "bits" can be written into the tube in $^1/_{30}$ second and can be read out many times at high speeds. This information can then be erased electronically and new data can be recorded.

Some of the applications for the storage tube are at present classified, but in commercial usage the tube is expected to be useful—for example, in fluoroscope and X-ray diagnostic work. X-ray beams passing through the body can be made to energise electrical circuits instead of exposing a photographic plate. Since only a very brief X-ray exposure time would be required, the danger to both patient and doctor of X-ray poisoning would be considerably lessened. Yet that brief interval would be sufficient to store an image on the tube which the physician may then examine at his leisure. He would also be able to study the image immediately, rather than waiting for photographic film to be developed. The stored image of the tube may be studied for as long as fifteen minutes before it begins to fade. Police departments may incorporate the tube into their "teletype" circuits in such a way as to transmit over standard telephone lines pictures of fingerprints, persons and articles of evidence. This method holds promise of being much more economical than conventional facsimile systems, and of being able to transmit photographs for the newspaper industry at high speed and low cost, maintaining their full half-tone qualities.

Industrial and Labour Notes

Amalgamated Engineering Union

The annual meeting of the national committee of the Amalgamated Engineering Union began at Blackpool last Monday, the opening session being addressed by the president, Mr. R. Openshaw. In the course of his address, Mr. Openshaw commented on wages and procedure and, in a reference to the settlement of the last claim, said that the employers had not been "such hard nuts to crack" as on some previous occasions. One thing that did give satisfaction, Mr. Openshaw added, was the fact that, although the employers' reply to the unions' case was rather belated, when the unions' and employers' representatives met on March 9th they were able to reach agreement on the same day. Mr. Openshaw went on to say that there was to be further joint consideration of a proposal to set the unskilled rate as a percentage of the skilled rate and, in fact, as far as possible, to express all rates as percentages of the skilled rate. There was a long way yet to go to get the wages structure the union wanted and the attendant problems of detail were likely to be extremely difficult to overcome, but, Mr. Openshaw said, he believed the unions were moving in the right direction.

Later in his address, Mr. Openshaw spoke about the public ownership of industry. He said that the union "Plan for Engineering" was not dead, and that there were signs that the T.U.C. and the Labour Party had come round much more to the unions' way of thinking. In the machine tool industry he had heard opinions expressed that the larger firms, making up well over three-quarters of the industry, should be publicly owned and controlled. The principle of public ownership, Mr. Openshaw continued, in order to secure efficient production and a better and cheaper commodity for the consumer, was no longer in doubt. But what, he thought, must receive much more attention was the "democratisation" of the publicly-owned industries. Joint consultation must be made to work, for until that was achieved there could not be expected development into the "inevitable next stage of full workers' participation in management." Managers and men, Mr. Openshaw asserted, needed to have a greater realisation of the benefits to the industry, the workers and to the consumers which could come from co-operation where the profit motive was absent.

Federation of British Industries

The annual general meeting of the Federation of British Industries was held in London on Wednesday of last week. The grand council's report, which was presented, described the past year as a period of high industrial activity with record figures of national production, a welcome rise in productivity, and very full employment. Further controls had been removed and private industry had shouldered the responsibility of developing its own enterprise. With the encouragement of the Chancellor of the Exchequer, the report added, private industry was expanding its investment with confidence in its future prospects.

In an address at the meeting, the retiring president, Sir Harry Pilkington, said that so often since the war there had been talk of the danger of "pricing ourselves out of markets." So often, it had not happened because there had been an increase in costs in other countries parallel to that which went on in this country, and there had been unexpected life in the sellers' markets. Sir Harry expressed the hope that costs here would increase less than elsewhere. What we certainly could not afford, he said, was that they increased faster than they did elsewhere. Permanent damage to the economy would follow, he emphasised, if scarcity value methods of pricing were applied to those things that seemed to be in permanent short supply, including manpower. The spiral of increases in costs and prices had lately been moving too fast and responsibility rested not only on those who asked, but on those who too readily yielded. A long sellers' market here had weakened the forces of restraint, and, Sir Harry thought, the increase in costs was the largest cloud on the horizon.

Sir Harry went on to say that it had been strongly impressed upon him by members of the F.B.I. that now, when costs were rising too fast, was the time for those engaged in industry and commerce to show real restraint, and when operating at capacity with a better overhead spread, to give the buyer a very large share of the resultant savings. At this time particularly, he observed, when the dangerous spiral could be speeded up or slowed down, the public interest was not served by raising prices above the level natural in more balanced conditions of supply and demand, rather was it served by responsible management deliberately holding them down. That principle, Sir Harry suggested, would command general agreement, but he felt sure that each firm must make up its own mind on how far it could continue to absorb extra costs. There could be no uniformity in practice, but he believed that voluntary far-sighted restraint in price policy was truly enlightened self-interest, if the future was kept in mind. In many industries, Sir Harry added, such a policy was greatly helped by co-operation in selling as well as in manufacturing.

Overseas Trade

The final figures of the United Kingdom's overseas trade in March, as shown by the Board of Trade accounts, give the value of exports as £260,300,000. The high level of exports achieved in January and February was, therefore, continued last month, the monthly average over the first quarter of this year being £247,300,000, or 10 per cent more than in the corresponding period of 1954. The value of imports averaged £335,100,000 a month during the first quarter and was, therefore, 22 per cent above the average for the comparable period of last year. The value of re-exports averaged £10,600,000 a month, and the trade deficit thus averaged £77,100,000 a month in the first quarter of this year, compared with £40,000,000 in the corresponding period of 1954.

In some comments on the area pattern of the United Kingdom's overseas trade, the Board of Trade says it was to be expected that the fall in exports in the last quarter of 1954 would be particularly marked in the sterling area. That area includes several of the more distant markets for which shipping was dislocated by the dock strike. Correspondingly, the resumption of a full flow of trade would be likely to be reflected most in the sterling area figures. In fact, total exports to the sterling area in the first quarter of this year increased by £19,000,000 a month, or 18 per cent compared with the last quarter of 1954. The average value in the first quarter, which was £127,000,000 a month, was 12 per cent more than in the corresponding period last year. But imports from the sterling area were also very much higher in the first quarter of this year, and at £147,000,000 a month, were 10 per cent greater than in the comparable period of 1954. Exports to the non-sterling area continued in the first quarter the increase already recorded in the last quarter of 1954, and at £131,000,000 a month (including re-exports) were 9 per cent more than in the first quarter last year. The dollar area, however, took less of our exports in the first quarter of this year than in the preceding quarter, and only 4 per cent more than in the first quarter of last year. This result, the Board of Trade says, followed from the failure, as yet, of exports to Canada to pick up from recession levels, and also from disappointing results in the dollar area outside North America.

Industry's Investment Plans

During the debate in Parliament last Monday on the motion for the Second Reading of the Finance Bill, the Economic Secretary to the Treasury, Sir Edward Boyle, said that the Government was anxious to collect from industry views about future prospects. One way of doing that, which had proved invaluable in other countries, was to invite a number of firms to give estimates of their investment intentions for a year or so ahead. It was proposed to introduce, in the immediate future, a simple request for information on those lines. Sir Edward said he was sure that the firms approached would co-operate fully in stating their plans as accurately as possible.

Sir Edward emphasised the Government's dependence on the information which flowed in from firms throughout the country for a properly balanced and up-to-date view of the economic situation. He said that sound economic policy must rest upon a statistical foundation which was largely made up of the various returns of production, employment, prices, orders on hand and so on which were supplied by firms to Government departments or to trade associations. In a free and competitive economy, Sir Edward added, it was more important than ever that the true facts should be quickly available and widely known.

Hematite Pig Iron

In reply to a question in the House of Commons on Monday, the Minister of Supply, Mr. Maudling, said that temporary difficulties in securing shipping space had reduced imports of hematite ore and had caused some shortage of hematite pig iron. Greater supplies of foreign ore were now coming in, and some imports of hematite pig iron were being arranged. The difficulties, the Minister added, had been "strictly temporary."

Railway Wages Dispute

Conversations between officials of the Ministry of Labour and representatives of the Associated Society of Locomotive Engineers and Firemen took place at the end of last week, but after them A.S.L.E.F. stated that the decision to take strike action as from midnight on Sunday, May 1st, was unaltered. The decision to strike was announced a fortnight ago following the rejection by the Railway Staff National Tribunal of a wage claim made by A.S.L.E.F. for footplate men, motormen and engine cleaners employed on British Railways. It has been asserted by the executive of A.S.L.E.F. that the British Transport Commission's latest wage offer—which was accepted by the two other railway unions—does not provide a satisfactory differential between locomotive men's wages and those of other grades.

The Railway Staff National Tribunal is the final stage of the accepted machinery of negotiation. The British Transport Commission directed the attention of A.S.L.E.F. to this fact last week and appealed for reconsideration of the decision to strike. The Commission expressed its readiness, in the light of the Tribunal's award, to operate retrospectively from January 10th the wage increases to locomotive staff which it made as part of the general railway wages revision. The Commission has also pointed out that the Tribunal had before it all the evidence and arguments presented by both sides, including the arguments concerning differentials which have been reiterated recently by A.S.L.E.F. Finally, the Commission has emphasised that to reject the findings of the independent tribunal, accompanied by notice of strike action, "is to undermine the whole procedure for the settlement of wages disputes."

On Tuesday last, representatives of A.S.L.E.F. were invited to discuss the situation with the general purposes committee of the Trades Union Congress. Afterwards, it was stated that the matter would be considered by the T.U.C. general council on Wednesday. It was also announced on Tuesday evening that A.S.L.E.F. had instructed its members employed by London Transport to continue their normal duties in the event of a strike. Members of the National Union of Railwaymen have also been advised by the executive of their union to continue to work normally should strike action be taken by A.S.L.E.F. As these notes go to press, there is no definite indication that the executive of A.S.L.E.F. has withdrawn its strike notice.

Personal and Business

Appointments

MR. A. R. COLLIE has been appointed sub-contracts officer of Westland Aircraft, Ltd., Yeovil.

MR. S. A. SPRAGG has been appointed sales representative of Slack, Sellars and Co., Ltd., Mowbray Street, Sheffield, 3.

MR. P. E. KUHL has been appointed to the board of the Iranian Oil Refining Company, in place of Mr. D. L. Hussey, who has resigned.

MR. R. GRESHAM COOKE has been appointed a director of Kerry's (Great Britain), Ltd., Warton Road, Stratford, London, E.15.

BLACKSTONE AND CO., Ltd., Stamford, Lincs, states that Mr. George Hallewell, M.I.Mech.E., chief engineer, has been appointed a director.

MR. D. W. L. MENZIES, managing director of Bonnington Castings, Ltd., has joined the board of Sigmund Pumps, Ltd., Team Valley, Gateshead, 11.

MR. A. E. H. BROWN has been appointed general manager of the Scottish Region of British Railways, in succession to Mr. T. F. Cameron, who is retiring in September next.

THE MARCONI INTERNATIONAL MARINE COMMUNICATION COMPANY, Ltd., announces the appointment of Mr. G. A. Dwyer as manager of the Port Said service depot.

MR. W. J. M. COOK has joined the staff of The Paterson Engineering Company, Ltd., Windsor House, Kingsway, London, W.C.2, to take charge of the industrial sales division.

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., states that Mr. E. G. Crossling has been appointed manager of the Coventry works, in succession to Mr. H. J. Armstrong, who has retired.

VISCOUNT BRACKEN, P.C., the Hon. Alexander Hood, Sir Eric Speed, K.C.B., and General Sir William Morgan, G.C.B., have been elected directors of Associated Electrical Industries, Ltd.

MACROME, Ltd., and HALLMAC TOOLS, Ltd., Wolverhampton, announce the appointment of Mr. J. M. Wimhurst as technical representative for South Lancashire, Cheshire and North Wales.

DOWTY GROUP, Ltd., Cheltenham, states that Mr. L. T. P. Banbury has been appointed a director of Dowty Equipment, Ltd. Mr. Kenneth A. N. Mills succeeds Mr. Banbury as secretary of that company.

RUSTON-BUCYRUS, Ltd., Lincoln, announces the appointment of Mr. N. A. Webster as domestic sales manager, in succession to Mr. A. H. Wade, who has retired. Mr. C. R. Scott has been appointed assistant manager.

ACHESON COLLOIDS Ltd., 18, Pall Mall, London, S.W.1, states that Mr. H. G. Davis has been appointed deputy works manager at the Plymouth works. Mr. J. B. MacLean has joined the export section of the sales department.

MR. E. J. ABBEY has been appointed export manager and Mr. J. D. Willcock, assistant export manager, of the small tools division of B.S.A. Tools, Ltd. The address of this division is P.O. Box 232, Montgomery Street, Birmingham, 11.

THE ATLAS DIESEL ORGANISATION announces the following appointments: Mr. Erik Ryd, technical director in charge of the design, research and experimental departments; Mr. J. A. Perham, managing director; Mr. J. C. Greig, managing director of the British company.

DR. H. W. CLARKE, chairman and managing director of James Booth and Co., Ltd., has been elected president of the Aluminium Development Association. Hon. Geoffrey Cunliffe, deputy-chairman and managing director of The British Aluminium Company, Ltd., has been elected vice-president.

PETTERS, Ltd., Staines, announces the appointment of Mr. D. K. Fraser as director and general manager. This follows the resignation of Captain R. C. Petter from the office of managing director. Captain Petter continues as a non-executive member of the board of Petters, Ltd., and a director of The Brush Group, Ltd.

MR. S. P. PRITCHARD, A.M.I.E.E., has been appointed resident partner in Bombay of Associated Consulting Engineers (India), of which firm Messrs. Kennedy and Donkin, of Westminster, are the principals. He succeeds Mr. A. C. Fielding, M.I.C.E., who has returned to this country to act as consultant in London to Associated Consulting Engineers (India).

Business Announcements

ALMIN, Ltd., states that its address is now Almin House, Stoke Poges, Bucks.

VOICE AND VISION, Ltd., has changed its address to 107, Baker Street, London, W.1 (telephone, Hunter 9933).

BORAX CONSOLIDATED, Ltd., has moved to Borax House, Carlisle Place, London, S.W.1 (telephone, Victoria 9070).

INSPECTION EQUIPMENT, 19, Broad Court, Drury Lane, London, W.C.2, has obtained the sole agency for "Fedrex" portable industrial X-ray units manufactured by Carl Drenck Electro-Technical Laboratories, Copenhagen.

THE HOYT METAL COMPANY OF GREAT BRITAIN, Ltd., has completed the equipment of a new factory near Sydney, Australia. Its subsidiary company there is now known as the Hoyt Metal Company of Australia Pty., Ltd., the address being 68–80, Hughes Avenue, Ermington, N.S.W.

COMPOFLEX COMPANY, Ltd., 26, Grosvenor Gardens, London, S.W.1, has opened an experimental and development establishment at Godalming, Surrey. Mr. J. Moseley, the technical director, is taking charge of the establishment, with Mr. D. J. Saunders as chief development engineer (hydraulics), and Mr. P. W. O'Brien, technical manager (special projects).

HEAD, WRIGHTSON AND CO., Ltd., Thornaby-on-Tees, has acquired from the British Metal Corporation, Ltd., the entire share capital of Colliery Engineering, Ltd., Sheffield, and its subsidiary, the Cupola Mining and Milling Company. Mr. Peter Wrightson has been appointed chairman, and Mr. L. W. Needham, managing director, of Colliery Engineering, Ltd., and Sir John Wrightson, Bt., becomes chairman, and Mr. A. Chilton, managing director, of the Cupola Mining and Milling Company.

Miscellanea

METEOROLOGICAL OFFICE REORGANISATION.—The Under-Secretary of State for Air has announced, in a written Parliamentary answer, the setting up of a committee to review the organisation of the Meteorological Office. Lord Brabazon of Tara has agreed to serve as chairman of the committee, the other members being Sir Charles Darwin, F.R.S., Major R. H. Thornton, Sir Folliott Sandford, and Mr. J. R. Simpson.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—At the annual general meeting of the Institution, Professor A. M. Robb was re-elected president and Mr. T. A. Crowe and Mr. H. H. Hagan were appointed vice-presidents, while those elected as members of council were Messrs. J. A. Campbell Brown, John Brown, I. C. Bridge, A. W. Davis and A. R. Mitchell, with Mr. N. M. Lindsay as associate member of council.

MACHINE TOOL SUPPLIES.—A question was addressed to the Minister of Supply on Monday as to whether the machine tool industry was now in a position to meet all anticipated home demand. In his reply, the Minister said that, despite decreased demands for the defence programme, the volume of the known and anticipated demand for machine tools for delivery to the home engineering industry this year was such that it would be necessary to continue to import machine tools.

ORGANISATION AND CONTROL OF PRODUCTION.—The first of a series of full-time courses on the organisation and control of production has recently ended at the Birmingham College of Technology. The courses, which last for six weeks, are arranged by the Department of Industrial Administration and are designed exclusively for staff who have completed their technical education and are being trained for production control responsibilities. The courses are limited to ten students each, and combine theoretical study and practical work. The latter for the most part takes the form of visits to factories, followed by "report and discussion" periods. It is stated that production control is defined as covering procedures designed to co-ordinate interpretation of sales and product engineering requirements; planning of manufacturing processes; work study; stock control; scheduling and control of supplies and factory work, and receiving, storing, handling and dispatch of material.

CONFERENCE ON STRESSES AND DISPLACEMENTS in STRUCTURES.—A conference on the "Correlation Between Calculated and Observed Stresses and Displacements in Structures" is to be held by the Institution of Civil Engineers on Wednesday and Thursday, September 21 and 22, 1955. Twenty papers will be presented and discussed in four separate sessions. After the official opening of the conference by the president of the Institution, Mr. David M. Watson, on the Wednesday, the rest of that morning will be devoted to discussions on the group papers, "Philosophy and Techniques of Testing," followed, after a luncheon break, by the second session, "Steel Structures." The third and fourth sessions, on Thursday, will be on "Concrete Structures" and "Earth Pressures and Movements." A registration fee of £2 will entitle participants to a copy of the preliminary and final volumes of the "Proceedings." Further information is obtainable from the Secretary, The Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1.

ALUMINIUM INFORMATION BULLETIN.—We have received from the Aluminium Development Association, 33, Grosvenor Street, London, W.1, a copy of *Information Bulletin No.* 7—"Machining Aluminium." This is a revised edition of the bulletin which was first published in 1944 under the title "Machining of Wrought Aluminium Alloys." The earlier publication dealt only with the machining of aluminium alloys in the wrought form, but the revised edition includes data for cast alloys, covers workshop practice in a wide range of industries, and takes into account the results of research and experience in machine tool design and operation over the last ten years. The bulletin deals with the machining characteristics of aluminium and then goes on to discuss alloy group classification, machines, tool materials, and cutting compounds and lubricants. Tool design problems are examined and there follows a review of data concerning such operations as turning, boring, parting, planing and shaping, milling, broaching, &c., together with recommendations regarding speeds, feeds and tool angles. The concluding section of the bulletin briefly discusses the common cause of distortion during machining and the precautions applicable.

RADIO-CONTROLLED TRAIN ON FRENCH RAILWAYS.—As we go to press we learn that on April 18, 1955, a train consisting of four carrriages hauled by the French Railways "BB 9003" electric locomotive and carrying neither driver nor passengers reached a speed of 74·5 m.p.h. while operated by radio control between Connerré-Beillé and La Ferté Bernard on the main line between Paris and Le Mans. Running alongside on a parallel track was a diesel railcar carrying Monsieur Corniglion-Molinier, French Minister of Public Works and Transport; Monsieur Louis Armand, the chairman of the French National Railway System, and Monsieur Charles Boyaux, the General Manager of the French Railways, accompanied by a party of technicians. Orders to release the brakes, to control the supply of current to the traction motors of the locomotive, and to apply the brakes at the end of the run were given verbally by radio telephone from the accompanying railcar to a radio control post set up on the substation at Sceaux-Boëssé, about halfway between the starting and finishing points of the run. The radio-frequency transmissions to carry out these orders were made from the control post to a receiving set which actuated a relay on the locomotive and, in turn, set the necessary mechanisms in motion. For this and other applications of radio in railway working the French Post Office has allocated wavelengths around 1m. Because starting and acceleration of the "BB 9003" (in common with some other French Railways electric locomotives) is automatic, only two kinds of remote control were necessary: one to operate the brakes and the other to regulate the supply of current to the traction motors. Two kinds of signal were necessary for the transmission of orders to the robot train. One of the orders was given by the carrier frequency without modulation and the other by the carrier frequency with modulation at approximately 1000 periods per second. The wavelength used was 1·9m.

Launches and Trial Trips

COMPLETION OF COASTAL MINESWEEPER.—The coastal minesweeper H.M.S. "Dunkerton," which was built by the Goole Shipbuilding and Repairing Company, Ltd., completed trials on April 23rd. The ship has a length overall of 152ft by 28ft beam and is propelled by two sets of Mirrlees diesel engines.

ANTI-SUBMARINE FRIGATE.—H.M.S. "Scarborough," a "Whitby" class anti-submarine frigate, was launched from the Walker yard of Vickers-Armstrongs, Ltd., on April 4th. The ship has a length overall of 370ft, a length between perpendiculars of 360ft, a beam of 41ft and a main armament of two 4·5in guns.

SAN PATRICCO, oil tanker; built by the Furness Shipbuilding Company, Ltd., for the Eagle Tanker Company, Ltd.; length overall 525ft 1½in, length between perpendiculars 496ft, breadth moulded 67ft 6in, depth moulded 36ft 5in, summer draught 29ft 1½in, deadweight 16,050 tons, loaded trial speed 14 knots; twenty-seven cargo oil tanks, one main cargo pump room, two 500 tons per hour cargo oil pumps, one 150 tons per hour stripping pump; two diesel-driven and one steam-driven 150kW generators, two 60kW motor-driven generators; two cylindrical multi-tubular boilers, one waste-heat boiler; one Sulzer single-acting, two-stroke oil engine, eight cylinders, 720mm diameter by 1250mm stroke, 5250 b.h.p. at 125 r.p.m. Trial, April 20th.

ANJOU, oil tanker; built by the Chantiers et Ateliers de Saint-Nazaire Penhoët for the Société Francaise des Transports Petroliérs; length overall 557ft 9in, length between perpendiculars 538ft 1in, breadth moulded 73ft 8in, depth 40ft 6in, deadweight 19,800 tons; two generators driven by 500 h.p. diesel engines; Penhoët-B. and W. single-acting, two-stroke diesel engine, nine cylinders, 740mm diameter by 1600mm stroke, 8300 h.p. at 115 r.p.m. Trial, April.

LEBU, cargo ship; built by the Ateliers et Chantiers de la Loire for the Compania Sud Americana de Vapores; length overall 488ft 4in, length between perpendiculars 452ft 8in, breadth moulded 60ft 7in, depth to main deck 30ft 3in, summer draught 27ft 8in, deadweight 10,500 tons; service speed 16·3 knots; five holds; one 30-ton, four 10-ton and twelve 5-ton derricks, electric winches; three 300kW diesel-driven generators; one set of C.E.M.-Parsons double reduction geared turbines, 7500 h.p. at 118 r.p.m. of propeller, two oil-fired Babcock and Wilcox boilers supply steam at 512 lb per square inch and 750 deg. Fah. Trial, April.

British Patent Specifications

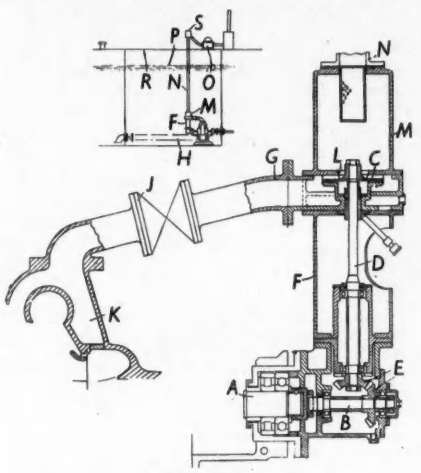
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

PUMPS

727,050. July 7, 1952.—PRIMING ARRANGEMENTS FOR CENTRIFUGAL PUMPS, Drysdale and Co., Ltd., and John Young, both of the company's address, at Bon-Accord Works, Yoker, Glasgow, Scotland.

A priming arrangement for a centrifugal pump according to the invention comprises a supplementary rotary impeller deriving its rotation from the main driving shaft of the pump, the impeller being interposed between the main suction pipe of the pump and an exhauster for air or gas. Referring to the



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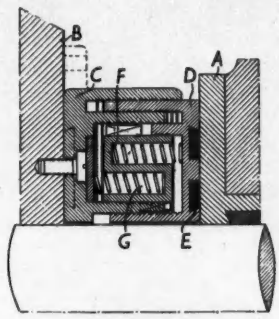
drawing, a centrifugal oil pump of the horizontal shaft type has at the outer end of the shaft *A* an extension *B*. A supplementary impeller *C* is mounted on the upper end of a vertical shaft *D* connected at the lower end to the shaft extension *B* through a mitre bevel gear transmission *E*. A branch connection *G* is led from the casing *F* above the top of the main suction pipe *H* of the pump. An isolating valve *J* is interposed in the branch connection *G*. *K* denotes gas or air vents from the main suction pipe *H*. The suction eye *L* of the impeller *C* is connected through a pipe *M* to the gas or air suction pipe *N* of a gas or air exhauster *O* which is placed above the highest surface level of liquid at *P* in a tank *R*. Should the exhauster *O* be operating normally when the main pump is running, but requiring priming, the supplementary impeller *C* allows air or gas to be drawn into the suction pipe *N*. When the liquid rises in the main suction pipe *H* of the pump to the level of the connection at the top of the main pump impeller eye liquid will be rejected when it reaches the periphery of the supplementary impeller *C* by reason of the forced vortex formed. The proportions of the supplementary impeller *C* and its peripheral speed ensure maintenance of a stable vortex above the maximum vacuum capable of being produced by the exhauster *O*. Hence, no liquid can be drawn into the exhauster. To provide for the exhauster *O* being started up before the main pump, or, alternatively, for the main pump stopping inadvertently while the exhauster is running, a float-operated valve *S* is interposed in the suction pipe *N* between the exhauster and the impeller. This valve *S* is so arranged that, on rising, the float opens a connection to atmosphere and breaks the vacuum, thus acting as a final barrier to the ingress of liquid. The float-operated valve *S*, being at the top of the suction column, merely forms an air escape and is not liable to stick. By reason of its accessible position and of its primary function as a "cut out," the valve does not interfere with the priming ability of the exhauster *O* in normal operation. The system described above may also be applied to centrifugal pumps of the vertical shaft type. —*March* 30, 1955.

MARINE ENGINEERING

726,001. April 17, 1953.—STERN TUBE SEALING DEVICE, Rudolf Johan van Dam, 50, Groen van Prinstererlaan, Enschede, Overijssel, The Netherlands.

The sealing device shown in the drawing registers on one side with the end face of the stern tube *A* and on the other side with the adjacent end face of the boss of the propeller *B*. It comprises two bushings *C* and *D*. The bushing *C* is secured to the boss of the propeller *B* by means of countersunk headed bolts, so that it rotates with the propeller. The bushing *D* has an end face with a white metal lining *E* in contact with the back end face of the stern tube *A*. The bushings engage one another for giving a seal by means of three concentric cylindrical sealing flanges or collars. These sealing flanges have cylindrical sealing faces, and in each of the faces there is provided a number of grooves for taking up a lubricant. Between the



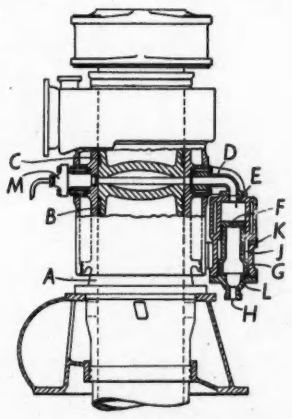
No. 726,001

bushings is a recess in which an annular spring-supporting bush *F* is accommodated. This bush has a rectangular cross section, and in it there are provided two rows of cylindrical bores *G* with their centre lines parallel to the propeller shaft, in such a way that in each row the successive bores open alternately to the left and to the right. In the drawing two bores are shown, each opening at a different side. Preferably, however, the bores of the two rows are so positioned relatively to one another that the adjacent centre lines are not in one and the same axial plane, but that each bore of the inner row lies between two adjacent bores of the outer row.—*March* 16, 1955.

INTERNAL COMBUSTION ENGINES

726,337. March 2, 1953.—CONSTANT-PRESSURE COMBUSTION, William Augustine Harper, Cuthbert Coulson Pounder, and Sir Frederick Ernest Rebbeck, of Harland and Wolff, Ltd., Queen's Island, Belfast, Northern Ireland.

The invention relates to internal combustion compression-ignition engines having a working cylinder with a single piston or opposed pistons working therein, and provides a simplified means to obtain constant-pressure combustion. In the drawing the opposed cylinders *A* have two pistons, the lower piston being shown at *B* and the upper piston at *C*. A lateral branch pipe *D* from the combustion space between the pistons opens into the upper end of an expansion cylinder *E* in which works an expansion piston *F* integral with a larger diameter intensifier piston *G*. An inlet *H* at the lower end of a cylinder *J*



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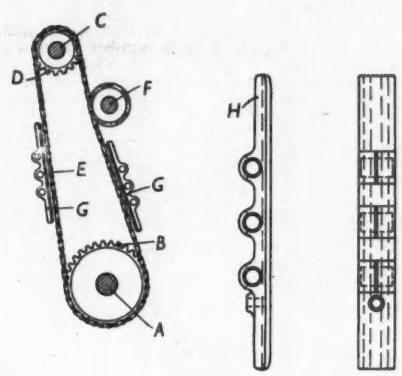
for the intensifier piston is provided for the admission of air drawn from the engine starting air reservoir through a reducing valve. An escape port *K* from the intensifier cylinder *J* is positioned so that a pneumatic cushion is provided for the pistons *F* and *G* at the end of their upward travel. One or more ports *L* may be provided beneath the piston *G* to connect the cylinder *J* with the inlet port *H*, so as to cushion the pistons *F* and *G* on their downward travel. *M* indicates the fuel injector. The drawing shows the engine pistons at the position of minimum compression space. As the engine pistons move apart on their power strokes, the piston *F* moves upwards, returning the contents of the expansion chamber *E* to the engine cylinders *A*, and it remains at the top of its stroke until compression and fuel injection repeats the engine cycle. The pressure applied to the underside of the piston *F* and intensifier piston *G* by air admitted through the port *H* is such that the piston *F* is held at the top of its stroke with sufficient pressure to allow the compression pressure in the engine cylinder to reach the required pressure for ignition of the fuel charge before the engine piston reaches the end of its compression stroke. During final inward movement of the engine piston, the piston *F* is forced downwards by the combustion pressure, thus ensuring substantially constant combustion pressure as the engine piston completes its compression stroke and commences its power stroke. A valve or cock may be fitted to the port *K* for regulating the pressure in the cushioning space above the port.—*March* 16, 1955.

POWER TRANSMISSION

725,984. March 27, 1953.—DAMPING DEVICES FOR LIMITING OSCILLATION OF GEAR CHAINS, Daimler-Benz Aktiengesellschaft, Stuttgart-Untertürkheim, Germany.

In the drawing *A* is the crankshaft of the internal combustion engine with a chain wheel *B*. *C* is the camshaft with a chain wheel *D*. The chain *E* which connects the two wheels *B* and *D* is maintained under



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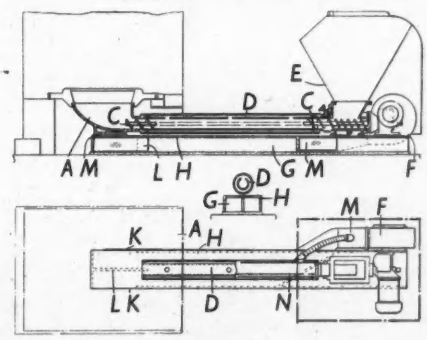
tension by a wheel *F*. On the two lateral sides of the chain, damping devices *E* are arranged to prevent excessive oscillation of the chain. Each device *G* consists of a metal body *H* with grooves for the chain. Rubber rails are inserted in the grooves. The body is provided with slit securing eyes for its attachment to the engine housing. Bores for connection to a lubricating device or system may be provided for the purpose of lubricating the chain. The rubber rails are of such a size that they contact solely with the rollers of the chain, whereas the link plates connecting the rollers can move freely on both sides of the rails.—*March* 16, 1955.

FURNACES

727,168. October 14, 1952.—MECHANICAL STOKERS, James Hodgkinson (Salford), Ltd., Ford Lane Works, Pendleton, Salford. (*Inventor: John Paton Lauder.*)

The invention relates to improvements in mechanical stokers of the underfeed type, the object being to supply the air to the plenum chamber centrally between its sides, thereby obtaining a substantially



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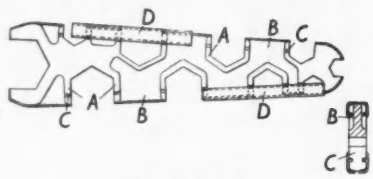
equal distribution of the air in the chamber. In the drawing *A* is the plenum chamber, *C* the screw or worm in the conveyor tube *D*, *E* the supply hopper and *F* the fan supplying air for combustion to the plenum chamber; the tube *D* shown is of the construction claimed in the Specification No. 727,169, but the present invention is equally applicable to stokers having conveyor tubes of ordinary construc-

tion. A channel *G* is formed in the base plate *H* vertically below and parallel to the conveyor tube *D*. In the construction shown in the drawings the channel *G* is formed by making the base plate *H* of channel shape and supporting it in an inverted position on the foundation. The sides of the channel *G* are cut away at *K*, where it enters the chamber *A*, so that air can flow evenly at both sides and a division plate *L* is also preferably provided between the cut away portion *K* of the channel to assist in the equal distribution of the air. The flat top of the base plate *H* serves to carry the bearing plates supporting the conveyor tube. The air supplied by the fan passes along the enclosed duct *M* to the channel *G* in the base plate and along the channel towards the plenum chamber, finally entering the chamber through the cut away portions *K* in the sides of the channel so as to obtain a substantially equal distribution of air in the chamber. This central air supply has the additional advantage that it allows the fitting of two ashpit clean-out doors, one on each side, thereby facilitating the removal of dust.—*March* 30, 1955.

TOOLS AND WORKSHOP APPLIANCES

727,181. December 10, 1952.—AN IMPROVED SPANNER, Leytonstone Jig and Tool Company, Ltd., 213, Piccadilly, London, W.1. (*Inventor : Alfred Goldman.*)

The object of the invention is to provide a multi-jawed spanner having a large number of separate jaws, which is simple to manufacture. The tool shown in the drawing can be conveniently formed by a forging about 9in long, ¼in thick



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and tapering from about 2¼in at one end to 1¼in at the other, the larger end being formed with the largest jaw, while the smaller end is formed with the smallest jaw, both being symmetrical with respect to the longitudinal axis of the spanner. The sides of the tool are straight between the ends and are formed with four jaws of intermediate size. The material adjacent to the jaw faces is thickened at *A*, thus forming webs *B* between the jaws to maintain adequate strength and yet to reduce the weight of material used. Parallel to the sides of the spanner and on both faces the thickened parts *A* are provided with grooves *C* which are in line with one another and of a depth nearly to the surface of the web. These grooves accommodate the legs of the channels *D* of C-section, which slide along the grooves. By sliding the channels to the same end the jaws at that end are covered and the hand is protected.—*March* 30, 1955.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1

PODGER SPANNERS

No. 2583 : 1955. Price 3s. net. The spanner dealt with in this specification is used in steel construction work, often at considerable heights. Although its legitimate purpose is the alignment of bolt and rivet holes in girders and beams, it is often used (quite wrongly) as a convenient means of climbing, since the podger can be inserted and the spanner used as a step or perch.

The standard specifies the dimensions and proportions of the spanners. Although it was not possible to specify requirements for a product which would be safe under all conditions of use, it is stated that manufacture in accordance with the standard will ensure that the spanners reach a desirable minimum standard of quality and performance.

PHENOLIC LAMINATED SHEET

No. 2572 : 1955. Price 4s. net. This standard specifies requirements for a number of types of phenolic laminated sheet which, in general, have good mechanical qualities, electrical insulating properties and resistance to corrosive influences. The tests specified are designed to assess and differentiate between the types ; they have not been selected in consideration of any particular use to which the material may be put.

The material is first divided into two groups : (*a*) where the mechanical properties in both directions are of the same order, and (*b*) where they are markedly different. The first group is then subdivided into four classes, according to whether the sheet is manufactured with an asbestos, cotton fabric, cellulose paper or wood veneer filter. Altogether fourteen different types of material are covered.

The standard specifies requirements for : appearance, flatness, tolerance on thickness and marking of the material. It also gives limits for the following physical properties :—Cross breaking strength ; impact strength ; water absorption ; electric strength (both flatwise and edgewise) ; insulation resistance after immersion in water, and crushing strength after heating. Methods of test are specified in the appendices.

SPRAYED METAL COATINGS : PART I, PROTECTION OF IRON AND STEEL AGAINST ATMOSPHERIC CORROSION ; PART 2, PROTECTION OF IRON AND STEEL BY ALUMINIUM AGAINST CORROSION AT TEMPERATURES BETWEEN 120 DEG. AND 950 DEG. CENT.

No. 2569 : 1955. Price 2s. net each. Part 1 of this specification covers the application of sprayed coatings of aluminium and zinc applied by various methods of spraying. It specifies the method of surface preparation and application of the coating, and gives specifications for the metals to be used in coating as well as requirements for the thickness and the adhesion of the coating. Appendices give the methods of test.

The second part is restricted to sprayed aluminium and provides three different methods for the three different processes whereby specific conditions of the finished coating are achieved. In all other respects it contains similar information to that given in Part 1.

SOLID DRAWN COPPER ALLOY TUBES FOR THE MANUFACTURE OF SCREWED FERRULES AND COPPER ALLOY SCREWED FERRULES FOR CONDENSER, EVAPORATOR, HEATER AND COOLER TUBES

No. 2579 : 1955. Price 2s. 6d. net. This new standard supersedes that part of B.S. 378 : 1941 which was omitted when the 1953 edition of that standard was published. B.S. 378 : 1953 specified requirements for five alloys from which condenser tubes can be made. These same five alloys are included in this standard, for the manufacture of screwed ferrules and the ferrules themselves. Of these five alloys, two (70/30 brass and 70/29/1 (Admiralty mixture) brass) were included in the 1941 edition of B.S. 378. The three new alloys included are : aluminium brass, copper nickel and aluminium bronze (7 per cent aluminium).

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

CHEMICAL SOCIETY

Thurs., May 5th.—Burlington House, Piccadilly, London, W.1, Meeting for the Reading of Original Papers, 7.30 p.m.

ELECTRIC RAILWAY SOCIETY

Thurs., May 5th.—Fred Tallant Hall, 153, Drummond Street, London, N.W.1, "British Electrification Possibilities," P. J. Taylor, 7.15 p.m.

ILLUMINATING ENGINEERING SOCIETY

Thurs., May 5th.—NOTTINGHAM CENTRE : E. Midlands Electricity Board, Smithy Row, Nottingham, Annual General Meeting, 6 p.m.

Tues., May 10th.—LONDON CENTRE : Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2, Annual General Meeting, "The Illuminated Chateaux of France," J. J. Chappat, 6 p.m.

INCORPORATED PLANT ENGINEERS

To-day, April 29th.—BIRMINGHAM BRANCH : Imperial Hotel, Temple Street, Birmingham, "Locomotive Testing," 7.30 p.m.

Tues., May 3rd.—LONDON BRANCH : Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2, "Heat Pumps and Refrigeration," Sir Oliver Lyle, 7 p.m.

Wed., May 4th.—LEICESTER BRANCH : College of Art and Technology, The Newarkes, Leicester, "Selection of Electric Motors," K. Broom, 6.30 p.m.——SOUTHAMPTON BRANCH : Polygon Hotel, Southampton, Selected Films, 7.30 p.m.

Thurs., May 5th.—PETERBOROUGH BRANCH : Campbell Hotel, Bridge Street, Peterborough, Talk by A. L. Berridge, 7.30 p.m.

Tues., May 10th.—MANCHESTER BRANCH : Engineers' Club, Albert Square, Manchester, "Notes on the Statutory Requirements of Steam and Pressure Vessels and Machinery," W. H. Mills, 7.15 p.m.

Wed., May 11th.—E. MIDLANDS BRANCH : County Hotel, Nottingham, Ladies Film Evening, 7 p.m.——GLASGOW BRANCH : Scottish Building Centre, 425/427, Sauchiehall Street, Glasgow, "The Human Factor and Productivity," Mrs. T. M. Ritchie, 7 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Tues., May 10th.—COVENTRY AND DISTRICT SECTION : Room A5, Technical College, Coventry, "Some Aspects of Cupola Operation," W. H. Bamford, 7.30 p.m.

INSTITUTE OF FUEL

Fri., May 6th.—S. WALES SECTION : S. Wales Institute of Engineers, Park Place, Cardiff, Annual General Meeting, 6 p.m.

INSTITUTE OF PETROLEUM

Wed., May 11th.—26, Portland Place, London, W.1, "Evaporation Losses from Petrol Storage Tanks in the U.K." E. H. Walker, R. M. Eltringham and A. Puttick, 5.30 p.m.

INSTITUTE OF REFRIGERATION

Thurs., May 5th.—Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, "Some Problems in the Design of Household Refrigerators," N. F. T. Saunders, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Wed., May 4th.—E. MIDLANDS CENTRE : Mechanics' Institute, Nottingham, Centre Annual General Meeting, 7.30 p.m.

Thurs., May 12th.—S. WALES GROUP : S. Wales Institute of Engineers, Park Place, Cardiff, "Paint-Synthetic Resin Finishes and Wet-on-Wet Spraying," C. Butler, 7 p.m.

INSTITUTE OF WELDING

To-day and Sat., April 29th and 30th.—The University, Nottingham, Spring Meeting, Technical Sessions and Works Visits.

INSTITUTION OF CIVIL ENGINEERS

To-day, April 29th.—YORKSHIRE ASSOCIATION : Great Northern Hotel, Leeds, Annual General Meeting, "Geophysical Surveying Applied to Geological and Engineering Problems," J. T. Whetton, 7 p.m.

Tues., May 3rd.—PUBLIC HEALTH MEETING : Great George Street, Westminster, London, S.W.1, "The Application of Prestressed Concrete to Water Supply and Drainage," R. H. Evans, 5.30 p.m.

Thurs., May 5th.—N.W. ASSOCIATION : Engineers' Club, Albert Square, Manchester, Annual General Meeting, 6.30 p.m.

Tues., May 10th.—RAILWAY MEETING : Great George Street, Westminster, London, S.W.1, "Some Notes on the Half-Through Type Plate Girder," P. S. A. Berridge and F. M. Easton, 5.30 p.m.

Thurs., May 12th.—STRUCTURAL AND BUILDING MEETING : Great George Street, Westminster, London, S.W.1, "Some Steel Structural Frames Designed on Plastic Theory," D. H. Little and A. Augustus Smith, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., May 2nd.—RADIO SECTION : Savoy Place, London, W.C.2, "A Simple Introduction to Telegraph Codes," H. V. Higgitt, 5.30 p.m.—S. MIDLAND CENTRE : James Watt Memorial Institute, Great Charles Street, Birmingham, "Fuel Supplies of the Future," E. F. Schumacher, 6 p.m.

Tues., May 3rd.—MEASUREMENTS SECTION : Savoy Place, London, W.C.2, "Medical Uses of Radioactive Isotopes," W. V. Mayneord, 5.30 p.m.——N. MIDLAND CENTRE : British Electricity Authority, 1, Whitehall Road, Leeds, 1, Annual General Meeting, 6.30 p.m.

Wed., May 4th.—Joint Meeting with the Institution of Civil Engineers and the Institution of Mechanical Engineers at the Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, Graham Clark Lecture, "The Engineers' Contribution to the Conservation of Natural Resources," Sir Harold Hartley, 5.30 p.m.

Thurs., May 5th.—UTILISATION SECTION : Savoy Place, London, W.C.2, "The Electrical Activity of the Brain," W. Grey Walter, 5.30 p.m.

Wed., May 11th.—RADIO SECTION : Savoy Place, London, W.C.2, Group of Papers on "Transistor and Other Semi-Conductor Devices," including "Junction Transistor Noise in the Frequency Range 7–50 kc/s," W. L. Stephenson; "Noise in Silicon Microwave Diodes," G. R. Nicoll, 5.30 p.m.

Thurs., May 12th.—EXTRA MEETING : Savoy Place, London, W.C.2, Discussion on "Image Intensification in Radiology," opened by W. J. Oosterkamp and G. M. Ardran, 5.30 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Fri., May 13th.—N.E. BRANCH : Crown Hotel, Clayton Street, Newcastle upon Tyne, Annual General Meeting, 6.15 p.m.; Annual Dinner, 7.30 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., May 4th.—GENERAL MEETING : Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, "Operation and Running Maintenance of Locomotives on the Nigerian Railway," F. H. Jaekel, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, April 29th.—GENERAL MEETING : 1, Birdcage Walk, Westminster, London, S.W.1, James Clayton Lecture, "The Transport Helicopter," Igor I. Sikorsky, 5.30 p.m.——SOUTHERN GRADUATES SECTION : Technical College, Guildford, Annual General Meeting, Film Show, 7.30 p.m.

Sat., April 30th.—WESTERN BRANCH : Physics Lecture Theatre, The Royal Fort, Bristol, James Clayton Lecture, "The Transport Helicopter," Igor I. Sikorsky, 6 p.m.

Fri., May 6th.—1, Birdcage Walk, Westminster, London, S.W.1, Benevolent Fund Extraordinary General Meeting, 5 p.m. GENERAL MEETING, APPLIED MECHANICS GROUP : "The Reversible Bending of Turbine Shafts with Temperature," A. Barker and F. W. Jones, 5.30 p.m.

Fri., May 13th.—GENERAL MEETING, HYDRAULICS GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, "An Investigation of Hydraulic Lock," J. Manhajm and D. C. Sweeney, 6.45 p.m.

INSTITUTION OF NAVAL ARCHITECTS

Tues., May 10th.—JOINT MEETING : Institute of Marine Engineers, 85/88, Minories, London, E.C.3, Symposium of Papers, "Advanced Machinery Installations Designed for the Maximum Saving in Weight and Space," 5.30 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Wed., May 4th.—ORDINARY MEETING : Institution of Electrical Engineers, Savoy Place, London, W.C.2, "The Development of Engineering Organisation and Efficiency—Work in the Engineering Department," H. R. Brown, 5 p.m.

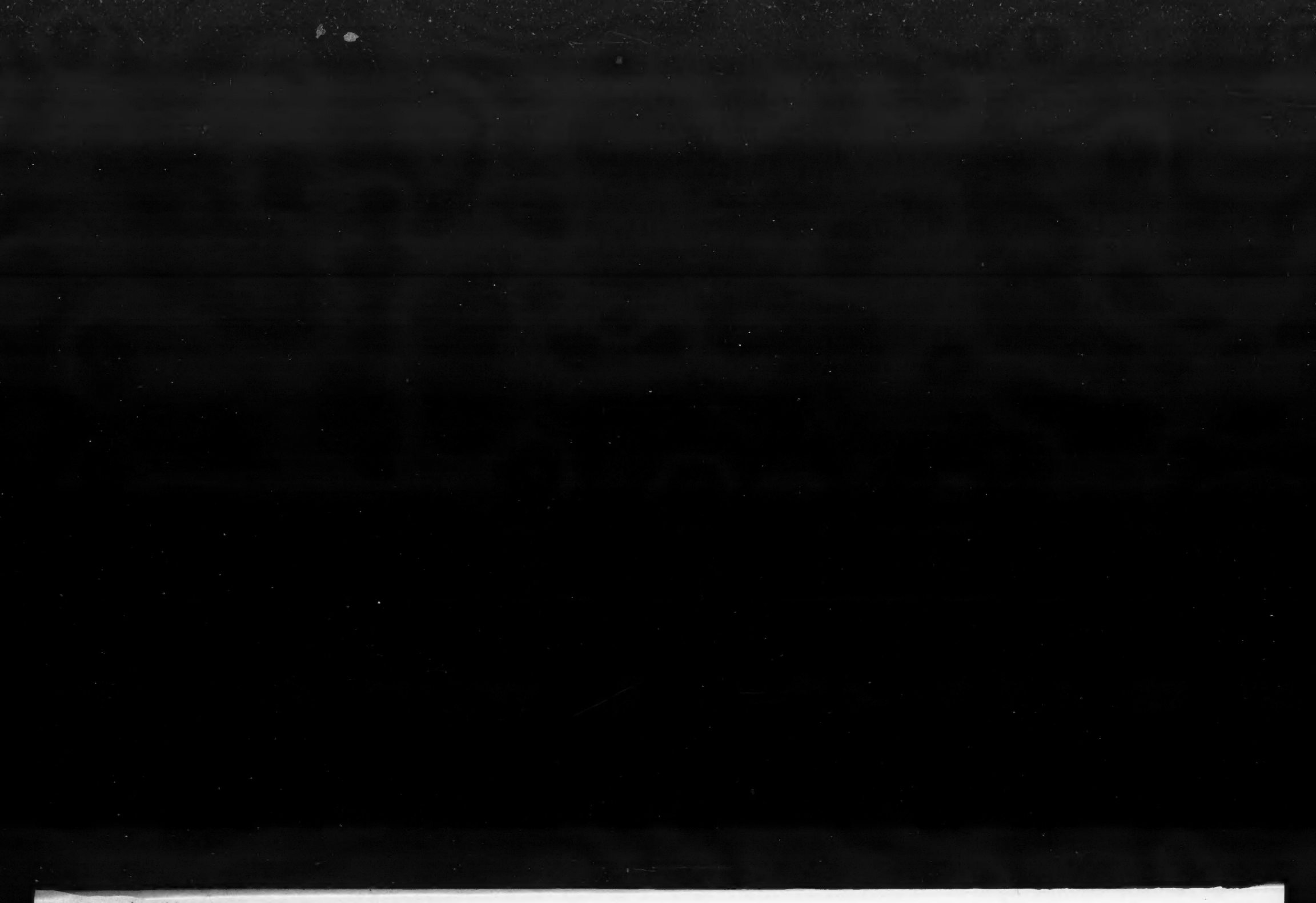
ROYAL AERONAUTICAL SOCIETY

Tues., May 3rd.—SECTION LECTURE : 4, Hamilton Place, London, W.1, "Plastic Structures," G. C. Hulbert, 7 p.m.

Wed., May 4th.—GRADUATES' AND STUDENTS' SECTION : 4, Hamilton Place, London, W.1, "Technical Aspects of Supersonic Aircraft Design," E. J. Catchpole and W. J. Eggington, 7.30 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., May 2nd.—ORDINARY GENERAL MEETING : 12, Great George Street, Westminster, London, S.W.1, "The City of To-morrow : Barbican and Beyond," Bryan Anstey, 5.30 p.m.

ROYAL SOCIETY OF ARTS

Wed., May 4th.—John Adam Street, Adelphi, London, W.C.2, "New Ways of Flying," Oliver Stewart, 2.30 p.m.